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# THE PREDICTION OF "IN VIVO" ICE HOCKEY PERFORMANCE AND THE DIFFERENCES BETWEEN A COMPETITIVE AND RECREATIONAL ICE HOCKEY TEAM BASED ON HOCKEY SKILLS AND PHYSICAL FITNESS IN TEN YEAR OLD BOYS

BY

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The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research, for acceptance a thesis entitled: "The Prediction of 'In Vivo' Ice Hockey Performance and the Differences Between a Competitive and Recreational Ice Hockey Team Based on Hockey Skills and Physical Fitness in Ten Year Old Boys", submitted by R. Wayne Yates in partial fulfillment of the requirements for the degree of Master of Science in Physical Education.

# DEDICATION

To a beautiful lady and my favorite wife, Anita.

To my parents, Ron and Kay, whose love and faith in me is never-ending.

Abstract

The present investigation was designed to observe the differences existing in twenty-eight ten year old boys of varying levels of hockey proficiency. Fourteen boys played on a hockey team (Mite $A_1$) that competed in an Edmonton Hockey League which was highly competitive and required superior hockey skills. The other fourteen boys represented a team (Mite $B_1$) which competed in a recreational-type hockey league in Edmonton. Both teams were tested on a battery of hockey skill tests at pre- and post-season. It was observed that the Mite $A_1$ team performed all the hockey tests faster than did the Mite $B_1$ team at pre-season, as well as at post-season. However, the Mite $B_1$ team improved at a greater rate on all hockey test executions over the course of the season. It was also observed that hockey tests requiring a greater degree of skill differentiated the teams more so than did the test measuring forward linear speed. When the hockey tests were correlated to "in vivo" hockey performance, as perceived by the respective team coaches, tests requiring greater degrees of skill demonstrated better relationships to "in vivo" hockey performance than did the test measuring forward linear speed.

The two hockey teams were also compared to one another based on age, height, weight, grip strengths, CAHPER fitness performance test items and physical work capacity ($PWC_{170}$) at post-season. No significant differences ($p > .05$) were observed between teams on age, height, weight, grip strengths and the shuttle run and standing broad jump of the CAHPER test battery. Significant differences were observed ($p < .05$) where the Mite $A_1$ team was superior on the one minute speed sit-up test and the flexed arm hang test of the CAHPER battery. The Mite $A_1$ team scored significantly better ($P < .01$) on the 50 yard dash and 300 yard run of the CAHPER test battery

and on the $PWC_{170}$ test expressed in terms of both kpm/min and kpm/kg/min. It was concluded that superior body size, muscular strength and explosive muscular power were not significant factors determining superior ice hockey playing abilities of children. It was suggested, however, that competitive ice hockey participation may have a positive influence on the strengths of the specific muscle groups used to ice skate. It was also concluded that the possession of superior aerobic and anaerobic functional capabilities is necessary to compete in an intense league of ice hockey in children. However, it could only be speculated that participation in a highly competitive league of ice hockey elicits a training effect on aerobic and anaerobic functional capabilities of children because pre-season initial fitness levels were not determined. When the Mite $A_1$ team was compared to other reported values of the CAHPER fitness performance test items and the $PWC_{170}$ test obtained by normal, healthy children, the Mite $A_1$ team was superior.

When the results of the hockey skill tests were correlated to the results of ages, height, weight, and the physical fitness variables, low correlation coefficients were observed. Height and weight were more related to forward speed skating than to hockey tests requiring greater degrees of skill. It was concluded that superior performances on the hockey tests were largely independent of physical fitness parameters measured off the ice. Superior hockey playing ability was determined to be a result of the influence of factors specific to the realm of the ice.

The two teams were grouped into one for determining the best equation of "in vivo" hockey performance using all the variables concerned. With the aid of multiple regression analysis, two hockey tests, a puck control skate and backward agility skate, accounted for 86% of the

variance of "in vivo" hockey performance. The predictor equation developed was as follows:

$$\hat{y} = -67.15 + 37.71\ (X_1) + 2.14\ (X_2)$$

where $\hat{y}$ = the predicted value of "in vivo" hockey performance

$X_1$ = the score obtained on the puck control skate

$X_2$ = the score obtained on the backward agility skate.

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# INTRODUCTION

Professional ice hockey in North America has been viewed by many as the epitome of hockey excellence. Until recent years, this viewpoint and the system in which the high calibre ice hockey participants are produced, has remained unquestioned. However, with the advent of international competition, North American ice hockey teams, coaches, management and fans have witnessed European philosophies applied towards the game and their subsequent successes on the ice. As a result, North American hockey traditions in teaching and coaching, as they exist today, necessitate objective examination and testing. One of the most logical places to begin is to examine the North American hockey system at the time in which the player is first introduced to the game. In the majority of cases, this occurs when the player is a pre-pubertal child.

The research available to date, which deals with the physical fitness capabilities of children, has varied both in terms of the actual fitness parameters investigated and the relationship of these fitness parameters to one another and to other variables. A number of studies, using children as subjects, have dealt with strength and general motor ability (Jones, 1946; Phillips, 1949; Bookwalter, 1950; Kane and Meredith, 1952; Asmussen, 1962; Hayden and Yuhasz, 1966; Montpetit et al., 1966; Alexander and Molnar, 1973; Crawford and Mason, 1974), while other studies have investigated the inter-relationship of strength to general motor ability (Everett and Sills, 1952; Rarick and Oyster, 1964; Berger, 1967; Berger and Mabee, 1967; Clarke and Borms, 1968).

Other investigations have dealt with the relationship of these parameters to age, physique and maturity levels (Seils, 1951; Barry and Cureton, 1961; Clarke and Harrison, 1962; Ismail et al., 1963; Clarke and Borms, 1968; Cureton et al., 1976). Research has also been designed to investigate the aerobic capabilities of children (Adams et al., 1961; Adams et al., 1961; Cumming and Cumming, 1963; Alderman, 1968; Howell and Macnab, 1968; Baggley and Cumming, 1972; Andersen et al., 1974; Bouchard, 1977). The aforementioned research on children dealing with physical fitness parameters and their associations with other variables has been conducted on the normal, healthy child without the child's activity levels in mind. Some researchers have investigated the relationship of strength and general motor ability to a variety of activity levels of children (Durnin et al., 1960; Clarke and Harrison, 1962; Bradley et al., 1966), while other researchers have investigated the trainability of the aerobic capabilities of children (Cumming et al., 1967; Ekblom, 1968; Andrew et al., 1972; Cunningham and Eynon, 1973; Eriksson et al., 1973; Massicotte and Macnab, 1974; Andersen et al., 1976; Stewart and Gutin, 1976).

The present investigation has been designed to investigate children's participation in the sport of ice hockey. Some researchers have investigated the fitness capabilities and characteristics of adult ice hockey players (Seliger et al., 1972; Green and Houston, 1975; Green et al., 1976; Houston and Green, 1976). Certain other studies have investigated the aerobic capabilities and characteristics of child hockey players (Tibault, 1974; Cunningham et al., 1976; Hamilton and Andrew, 1976; Gill, 1977; Shkhvatsabaya, 1977; Turcotte, 1978). The research available on the sport of ice hockey has also dealt with the

designing of hockey skill tests and the subsequent testing of hockey players using these tests (DiVincenzo et al., 1960; Alexander et al., 1963; Doroschuk, 1965; Hache, 1967; Merrifield and Walford, 1969; Hansen 1970; Larviviere et al., 1976; Gill, 1977; Turcotte, 1978). However, very little research has been conducted to examine the difference between similar aged child hockey players, having varying levels of hockey proficiency, on objective measures of hockey performance and non-specific hockey physical fitness parameters (Turcotte, 1968). Nor has there been much research conducted that attempted to predict a child's "in vivo" hockey performance from the results of both specific and non-specific hockey variables (Jobin, 1975).

## Purpose of the study

The purpose of this investigation was to determine the differences, if any, between a highly competitive hockey team of ten year old boys and a recreational hockey team of ten year old boys on a battery of hockey skill tests at pre- and post-season. Any improvements on test executions from pre-season to post-season were also observed. The post-season hockey test results were validated by comparing the results to the coaches' subjective evaluations of "in vivo" hockey performance. Also, the specificity of individual differences to the hockey tests performed at post-season were examined.

Another purpose of this investigation was to determine if any differences existed between teams at post-season on a number of physical fitness parameters. In turn, the results of these parameters were compared to the results of the hockey tests and "in vivo" hockey performance and these inter-relationships were examined.

A final purpose of this investigation attempted to predict "in vivo"

hockey performance from the results of all the tests variables.

# REVIEW OF THE LITERATURE

## Grip Strength

The grip strength test serves as an excellent field instrument to evaluate strength. Due to the compactness of the grip strength dynamometer, it is easily transportable. The test is easy to administer, supplies a direct measure of applied force, and does not require elaborate laboratory equipment. Though the grip strength test is hardly a satisfactory measure of total body strength, the relationship is reasonably good (Phillips, 1949; Clarke, 1959; Tinkle and Montoye, 1960). The grip strength test has also been found to be reliable (Montpetit et al., 1966).

The bulk of grip strength research has dealt with investigating the relationship of body size and age to grip strength (Bookwalter, 1950; Everett and Sills, 1952; Pierson and O'Connell, 1962; Montpetit et al., 1966; Schmidt and Toews, 1970; Alexander and Molnar, 1973). Other studies have investigated the relationship of a child's maturity level and body type to grip strength (Jones, 1946; Clarke et al., 1961; Clarke and Harrison,1962). Investigations have also been conducted examining the influence of physical activity on grip strengths in adult men (Tinkle and Montoye, 1960; Pierson and O'Connell, 1962) and children (Gill, 1977; Turcotte, 1968).

Schmidt and Toews measured the grip strengths of 1128 normal adult males and 80 normal adult females. The age range was 18 to 62 years. The age, height, weight, and hand dominance were recorded for each individual. It was found that the major hand scored higher than the

non-dominant hand in both males and females and at all ages. It was also found that grip strengths increased with age. For the men, it increased up to age 32 years. For the women, it increased up to age 40 years. After these ages, the grip strengths slowly began to decrease and continued to decrease to age 62 years. The heights and weights were found to be related to grip strength as well. In particular, the grip strengths of the men increased up to a height of 75 inches and a weight of 215 pounds. The finding that grip strengths increase with age, height and weight of adult populations is well founded (Bookwalter, 1950; Pierson and O'Connell, 1962; Schmidt and Toews, 1970).

The question was raised by Everett and Sills (1952) as to what component of physical stature plays a more important role in grip strength achievement. A number of anthropometric measurements were taken of the hand in 400 students ranging in ages from 14 to 29 years. The age, height and weight of each individual was also recorded. Multiple and partial correlations were calculated. The partial correlations observed demonstrated that greater reductions in correlation coefficients occured when either height, weight and one of the hand measurements were held constant. It was also observed that the correlation between weight and grip strength was reduced to a lesser extent through partialling procedures than were the correlations between grip strength and any other variable. Age had little affect on grip strength when other variables were held constant.

Though the addition of any variable to a multiple regression equation produced higher multiple correlations, it was concluded that body weight has the greatest affect on grip strength of post-pubertal populations. The size of the hand was also found to be of importance,

as a result, the investigators suggested the use of adjustable hand grip dynamometers for future grip strength investigations.

The greater influence of weight on grip strength as compared to height and age in post-pubertal populations, has been substantiated by others (Bookwalter, 1950; Tinkle and Montoye, 1960; Pierson and O'Connell, 1962). Tinkle and Montoye (1960) state that grip strengths of post-puberty individuals are not only related to, but probably dependent on body weight, while height and age are indirectly related to grip strength.

The finding that weight is more influential on grip strength than height is not substantiated by grip strength studies on pre-pubertal children. In fact, quite the opposite is found in pre-pubertal children.

Montpetit et al. (1966) collected grip strength scores on 485 boys and 423 girls, age 8-17 years, in the years 1963 to 1964. These results were then compared to results obtained in the year 1899 in the same city - Saginaw, Michigan. The latter sample involved 1507 boys and girls, age 10-18 years. The results for the age 10 boys (N=53, 1963-1964) for height, weight and highest grip strength of either left or right hand were 138.7 $\pm$ 6.8 cm, 33.8 $\pm$ 5.2 kg and 17.4 $\pm$ 3.0 kg, respectively. The results for the 1899, 10 year old boys were very similar. For the 10 year olds of the 1964-1965 study, grip strength correlated with height and weight with respective r values of .60 and .45 (both significant $p < .05$). When height was partialled out, weight had a zero correlation with grip strength. When weight was partialled out, height had a correlation with grip strength of .45 ($p < .05$).

In general, the findings suggest that, up to age 11, height is more closely related to grip strength, after which, weight plays a more

important role. In children, body size and grip strength are related when age affects are eliminated.

This finding is further substantiated by Bookwalter (1950) and Asmussen (1962) where at younger ages, height is more related to grip strength and as individuals get older, weight plays a more important role.

In a study conducted by Jones (1946), the relationship of the level of maturity to grip strength was investigated. The sample consisted of boys ranging in age from 11 to 17 years. It was found that the early maturing boys demonstrated superior grip strengths when compared to late maturing boys. For the 11 year old group, the mean right and left grip strengths were 25.14 kg and 23.46 kg, respectively.

The fact that early maturing boys score higher on grip strength tests has been further elucidated by Clarke and Harrison (1962). This investigation tested 273 boys aged 9, 12 and 15 years. Each age group was further divided into maturity groups as determined by hand-wrist x-rays. The maturity groups were denoted either retarded, normal or advanced. In terms of grip strength, the results showed that in all age groups, the advanced maturity boys scored significantly higher on grip strengths as compared to the retarded maturity boys. When the advanced group was compared to the normal group, the advanced group scored higher but the difference was not significant.

In general, boys who are more advanced in terms of maturity at a certain age level score higher in grip strength as compared to boys who are not. This has been further substantiated by Clarke et al. (1962).

In light of this, Beunen et al. (1974) found that differences between advanced and retarded maturity groups are strongly marked for

static strength but not as strongly marked for explosive strength. Further to this, Berger (1967) found that dynamic strength is more highly related to motor ability than static strength in children.

In terms of maturity levels, the more mature boys, at a given age, are superior in terms of physical size (Jones, 1946; Clarke and Harrison, 1962). It is highly likely, that the more mature boys score higher on grip strength tests compared to late maturing boys of the same age due to body size related factors.

In a study conducted by Tinkle and Montoye (1960), the relationship between grip strength and achievement in physical education was investigated. A total of 635 university students enrolled in a variety of physical education courses were tested. The results showed that grip strength is significantly related to achievement in physical education courses as measured by grades of performance. The hypothesis that physical activity influences grip strength has been confirmed by Pierson and O'Connell (1962) when athletes were compared to police recruits and police veterans.

Turcotte (1968) investigated longitudinal changes of grip strength in boys aged 8 to 12 years. One group of boys were from a team involved in a highly organized, competitive leage of ice hockey and grip strengths were collected starting at age eight and collected annually to age 12. In the first two years, a control group of non-hockey participants were used to compare grip strength values. In the next three years, a group of boys from a team engaged in a recreational league of ice hockey were used to compare grip strengths. Results showed that the grip strengths of the competitive group scored consistently higher than the control groups at all ages. When grip strengths of the competitive and less

competitive hockey groups were compared to other studies on age-matched children, both groups showed high levels of grip strength. It was probable that participation in the sport of hockey produces a positive influence on grip strengths of children over and above children who are not necessarily engaged in competitive sports programs. This gains further support considering that the level of physical activity of children has been shown to influence overall strength (Alexander and Molnar, 1973), although the form of physical activity and the primary muscle groups used has a preferential influence on the strength of certain muscle groups.

In summary, grip strengths of adult males are superior to their female age-matched counterparts. Generally speaking, the grip strength of the dominant hand is greater than that of the non-dominant hand in men and women. This difference is not as profound in female adult populations. The grip strength of adult men and women increases with increasing age, height and weight. This trend hold true to a certain age, height and weight, where at that time, decreasing grip strengths are evident. The decreasing trend has been attributed to the probable effects of the aging process. Particularly in adult men, weight influences grip strength more so than age or height. In pre-puberty boys, height appears to play a more decisive role.

It is also evident that the level of maturity within a particular pre-pubertal age group has a positive influence on grip strength. The early maturing boys display superior grip strengths. This is attributed to increased anatomical dimensions on the part of the early maturing boys. It is also probable that the early maturing boys experience greater improvements in the central nervous system which in turn has a positive

influence on grip strength.

The review of grip strength literature also points out that physical activity has a definite positive influence on grip strength.

CAHPER fitness performance items

A number of studies involving children have been conducted comparing results obtained on one or any number of the CAHPER fitness performance test items to a variety of variables. Most studies seem to be concerned with the relationship of age, physique, level of maturity and body composition to fitness performance test items (Seils, 1951; Clarke et al., 1961; Barry et al., 1961; Clarke et al., 1962; Ismail, et al., 1963; Montoye et al., 1972; Beunen et al., 1974; Ellis et al., 1975). Other studies have looked at the relationship of specific strength measures to performance of general fitness-performance tests (Clarke and Borms, 1968; Berger and Mabee, 1967; Baumgartner and Zuidema, 1972). Still, other investigations observed differences in performance of general physical fitness tests as related to athletic participation (Clarke et al., 1961; Clarke et al., 1962; Bradley et al., 1966).

Ellis et al. (1975) conducted an investigation concerned with three physical performance tests: the standing broad jump, one minute speed sit-ups and flexed arm hang tests. A total of 106 boys were tested on all three performance tests over a seven year period (10 through 16 years of age). Results indicated improvements on the three performance tests over the seven year period. These improvements were found to be significant ($p < .001$). For the 10 year olds, mean results on the standing broad jump, flexed arm hang and bent knee sit-ups were 164.08 cm, 30.6 secs and 37.8 no/min, respectively. The correlation coefficients, at

age 10, for sit-ups vs standing broad jump, sit-ups vs flexed arm hang and flexed arm hang vs standing broad jump were .429, .437 and .314, respectively. The correlation coefficients were significant at all ages and were similar to the 10 year olds for the other age groups. Although the correlations were significant, they were still somewhat low. The investigators concluded that the low correlations reflect a high degree of specificity of individual differences among the three performance measures.

In the same investigation, height and weight were compared to performance test results. The correlation coefficients were generally low for all comparisons and at all ages. There was a trend for the data of both height and weight correlations, to form an inverted "u" relationship during the seven year span. This was attributed to changes in the homogeneity of the group in body stature, possibly due to pubertal effects. The relationship of the level of maturity and somatotype to performance was also investigated. Results indicated that there was no significant difference between early and late maturers on the sit-ups and flexed arm hang ($p > .05$) but the early maturers were significantly superior in the standing broad jump ($p < .05$). Individuals displaying higher skin folds were significantly inferior to those individuals displaying lower skin folds on all three performance tests ($p < .01$). There was not a significant difference between ectomorphs and mesomorphs on standing broad jump and sit-ups ($p > .05$). The ectomorphs were found to be significantly superior to mesomorphs on flexed arm hang performance ($p < .05$).

Latchaw (1954) investigated the relationship existing between age, height and weight to a number of fitness performance tests. Of particular

concern were the results obtained on the standing broad jump (barefoot) and shuttle run (three interval distances of 20 feet). Subjects were of grades 4, 5 and 6 in an elementary school. Of the 10 year olds in grade 4 (N=31), a mean of 54.48 inches was obtained for the standing broad jump. Of the 10 year olds who were found in grade 5 (N=53), a mean of 54.92 inches was obtained on the same test. When all the boys of the three grades were grouped as one, correlation coefficients were obtained for age vs standing broad jump ($r = .35$), age vs shuttle run ($r = .33$), height vs standing broad jump ($r = .29$), height vs shuttle run ($r = .07$), weight vs standing broad jump ($r = .04$), and weight vs shuttle run ($r = .01$). It was concluded that height and weight factors in general, do not show as strong a relationship to performance as age.

In a study conducted by Ismail et al. (1963), factor analysis revealed that percent lean body weight was the most important item from the "body fitness" factor. Included in the factor of "body fitness" were the standing broad jump and 50 yard dash, among a number of other fitness items. Eighty-one boys, aged 10 to 12 years, were utilized for subjects. There was a total of 40 variables ranging from physical measures to balance and general motor ability tests. The simple correlation coefficients obtained for age, height and weight to the 50 yard dash and standing broad jump were: age vs 50 yard dash ($r =-.197$), age vs standing broad jump ($r = .300$), height vs 50 yard dash ($r = -.253$), height vs standing broad jump ($r = .309$), weight vs the 50 yard dash and standing broad jump were .055 and .053, respectively. Lean body weight (lbs) correlated with the 50 yard dash and standing broad jump with r's of -.556 and .573, respectively. Lean body weight expressed as a percentage produced r's of -.549 and .437 on the 50 yard

dash and standing broad jump, respectively. Age, height and weight factored out under the Growth and Maturity factor. Lean body weight in pounds also factored out under this factor. As mentioned previously, lean body weight (%) factored out the highest in the "Body Fitness" factor (.84) while the 50 yard dash factored out second (-.74) and the standing broad jump factored out third (.69). It was concluded that in the assessment of body fitness pertaining to pre-adolescent boys, lean body weight expressed as a percentage is the most important factor. Subjects high on this factor tend to score better on other fitness parameters. A point of interest was that balance did not correlate well with age, height, weight, 50 yard dash and the standing broad jump.

Seils (1951) found that constant negative correlations resulted when comparing body weight to standing broad jump over the ages of six to nine years. Low correlations were also obtained when weight was compared to the 40 yard dash in the same age range. Similar low correlations were obtained when comparing height and age to performance in the 40 yard dash and standing broad jump. Correlation coefficients were age, height and weight vs standing broad jump (.125, -.053, and -.181, respectively); age height and weight vs 40 yard dash (.205, -.059 and -.131, respectively).

In a study conducted by Clarke et al. (1968), the relationship of high, average and low gross and relative strength to maturity, physique, body size and motor performance was observed. A total of 722 boys served as subjects and were distributed by age as 10 year olds (N = 224), 13 year olds (N=249) and 15 year olds (N=249). The differences between the standing broad jump means obtained by the different strength groups at the three ages were significant ($p < .05$), except when comparing

average to low groups at age 10 years. For the 60 yard shuttle run, significant differences were obtained with two exceptions, high-average group at 16 years and average-low group at 10 years. In all three age groups, the high strength groups had the superior means. Results also showed that the higher strength groups had the higher means on maturity and body size measures at the three age groups. In terms of somatotype, the mesomorphy means were related positively to the groups of high strength at all ages. Comparisons based on cable-tension strength generally produced t rations where the highest t ratio was found between high-low groups and the lowest t ratio, between average-low groups.

On 53 male college students, Berger and Mabee (1967) examined the relationship between results of the AAHPER youth fitness test and total dynamic strength as determined by performance on a number of barbell exercises (maximum weight lifted in one repetition). A correlation coefficient of .564 ($p < .001$) was obtained between total dynamic strength and the AAHPER youth fitness test. They concluded that dynamic strength plays a relatively high importance in the performance of this fitness test. This is similar to results obtained by Larson (1940).

Montoye et al (1972) utilized 1147 boys from grades 4 through 12 in a study to determine the relationships of age, height and weight to the AAHPER fitness test, trunk flexion and trunk extension. The correlation coefficients obtained for age vs bent arm hang, standing broad jump, shuttle run, sit-ups and 50 yard dash were .49, .72, -.63, .25, and -.73, respectively. Height vs the same performance tests were .34, .70, -.59, .25 and -.69, respectively and weight vs the same were .18, .52, -.42, .13 and -.50, respectively. Stepwise multiple regression and partial correlations were also computed. It was found that age

and height or any combination of age, height and weight accounts for little more of the variance than age does alone.

A study to determine if significant differences in structural measures, muscular strength tests and explosive muscular power exist between boys who are advanced, normal, and retarded in maturity (as determined by hand-wrist x-ray) was conducted by Clarke et al (1962). A total of 273 boys, 9, 12 and 15 years of age served as test subjects. A number of structural and strength measures were collected. Grip strength, height and weight were a few of the many variables. To measure explosive power, the standing broad jump test was utilized. Although means were not presented, t ratios for the differences between the means were presented at each age group. Results showed that the highest and most consistently significant differences on all experimental variables at all three ages were obtained when the advanced and retarded maturity groups were compared. The differences between the means of the normal and retarded maturity groups were next in significance while the normal and advanced maturity groups were least in significance. In all instances, the more mature group had the higher mean.

Cureton et al. (1976) conducted an investigation which was designed to evaluate the relationship between the AAHPER youth fitness test to measures of physical development. A total of 49 boys ranging in age from 8 to 11 years ($\overline{X}$ = 9.9) were tested. The mean scores obtained on height, weight, sit-ups, shuttle run, standing broad jump and 50 yard dash were 141.6 cm, 34.9 kg, 76.2 no/min, 11.2 secs, 62.3 in, and 8.6 secs, respectively. The correlation coefficients between age and sit-ups, shuttle run, standing broad jump and 50 yard dash were .06, -.42, .57, and -.33, respectively. For weight vs the same and height vs the

same the correlations obtained were -.23, -.09, .13, -.02 and -.12, -.18, .32, -.21, respectively. A correlation of .285 was significant at the .05 level. Levels of body composition measurements which included skin fold measures, body density and body potassium contribute significantly to the prediction of most AAHPER test items over and above that contributed to age, height and weight (as determined by multiple regression analysis). When age, height and skin folds were held constant, an increase in body weight was associated with better performance.

Clarke et al (1962) conducted an investigation on boys where the primary purpose was concerned with observing changes in the level of maturity, structural measures, strength measures (which included grip strength) and motor ability measures (60 yard shuttle run and standing broad jump) from ages 9 to 15 years. A sample of 40 boys at each age group were tested. In general, results showed increases of strength and motor ability with age and these increases were in turn related to increases of maturity and body structure. However, an interesting finding resulted when this group of boys were compared to normal populations based on the "Physical Fitness Index" test. This sample was found to be superior. The fact that this sample of boys participated in a highly structured and strenuous physical education program, led the investigators to conclude that the nature of the physical education program may be a significant factor affecting the status of their musculatures. As a result, the various growth curves for the strength and motor tests might well be affected by muscular superiority. The means for the standing broad jump at age 10 was 142 cm.

Another investigation by Clarke et al. (1961) contrasted maturational, structural, strength and motor traits with different levels

of athletic ability. Subjects were from the upper elementary grades and junior high school grades, and all were boys. The sports which the boys were involved in were football, basketball, baseball, wrestling and track and field. The non-participants were boys who had tried out for the various teams yet were unable to make the team. Ahtletic ability was evaluated by the teams' respective coaches. In the standing broad jump, for boys aged 10 years, the differences between the means were significant ($p < .05$) for outstanding athletes vs non-participants. At the same age group, the comparison of the means of the regular athletic ability group to non-participants on the same test were not significant ($p > .05$). Though the study did not attempt to determine the effects of participation in interschool athletic teams upon boys, the conclusions were that those individuals who were participating at both elementary and junior high school levels, were definitely superior in maturity, body size and build, both absolute and relative (to weight and age) muscular strength, and explosive power (standing broad jump).

The finding that boys involved in more regimented training programs score higher than boys who are not is substantiated by Turcotte (1968).

Kane and Meredith (1952) determined the standing broad jump ability of 560 children who were enrolled in nine elementary schools of Eugene, Oregon. Of the children, 80 of each sex fell within the ages of 10 years to 11 years. The children jumped barefoot. The reliability of the test for boys aged 11 years was very high ($r = .99$). The mean for 11 year old boys was 59.8 in. They found that boys jumped farther than girls and that jump lengths increased with age.

Barry and Cureton (1961) found that with boys aged 7 to 11 years, within each age group, power, endurance and dynamic shoulder strength

were related to motor performance but were not related to morphological measurements. One of the power tests was the standing broad jump. The finding that morphological variables do not influence dynamic motor ability to any appreciable amount has been further substantiated by Rarick and Oyster (1961).

In a study conducted by Cureton et al. (1976), the relationship between the AAHPER youth fitness test and physical development in young boys was investigated. A total of 49 boys, eight to 11 years, served as test subjects. The mean age was 9.9 years. Particularly, the results for height, weight, sit-ups (no), shuttle run, standing broad jump and 50 yard dash were 141.6 cm, 34.9 kg, 76.2, 11.2 sec, 62.3 in and 8.6 secs, respectively. The results of the correlation analysis produced r values as follows: age vs sit-ups, shuttle run, standing broad jump, and 50 yard dash were -.06, -.42, .57, and -.33, respectively; height vs the same were -.12, -.18, .32 and -.21, respectively; weight vs the same were -.23, -.09, .13 and -.02, respectively. The results of body composition comparisons (lean body weight) demonstrated that lean body mass is more important in determining the AAHPER test items than age, height and weight. It was also found, by taking the performance test scores as a group and correlating this to body size and body composition measures, that 79% of the variations in performance can be accounted for by a combination of physical development variables. Note, however, that the correlations of age, height and weight to performance tests are not that high (the highest variance explained is by age vs 50 yard dash; 32%).

Cumming and Keynes (1967) and Crawford and Mason (1974) found that the CAHPER fitness performance test shows little or no correlation in

its present form with standard laboratory measures of endurance in average children.

In summary, it is found that physical fitness performance tests increase with age and body size. When boys who are similar in age and body size are compared on performance tests, the relationship of these variables to performance is small, despite the large variation in scores that may be observed. This phenomenon may be attributed to body composition factors. Although boys may weigh the same absolute gross body weight, the relative amount of lean body weight may be different. As a result, variations in performance scores may be observable because of the contribution from greater muscle mass. It is also evident that variations in test scores may be attributable to levels of physical activity. The CAHPER fitness performance test shows little relationship to physical work capacity tests.

## Physical Work Capacity

The fact that exercise programs of varying intensities and duration enhance the aerobic functional powers of adult man has been well-established (Cureton and Phillips, 1964; Pollack et al., 1969; Wilmore et al., 1970). In light of the fact that the aerobic fitness of children has been observed to decrease with age in certain select populations (Bailey, 1973) investigations of the aerobic fitness in children in recent years, have increased in number. Pertaining to the physical working capacities of children, a number of studies have erupted with the purpose of establishing norms (Adams et al., 1961; Adams et al., 1961; Cumming and Cumming, 1963; Howell and Macnab,1968; Macek et al., 1971). Other studies have investigated the trainability of aerobic fitness in children (Ekblom, 1969; Daniels and Oldridge, 1971;

Cunningham & Eynon, 1973; Massicotte and Macnab, 1974; Stewart and Gutin, 1976; Weber et al., 1976). There have been some investigations dealing specifically with child hockey players (Cunningham, 1976; Hamilton and Andrew, 1976; Shkhvatsabava, 1977). Other investigators (Seliger et al., 1972; Green and Houston, 1975; Green et al., 1976; Houston and Green, 1976) have attempted to determine the metabolic characteristics of adult ice hockey players.

In a cross-sectional study by Adams et al. (1961) 120 boys and 123 girls from Los Angeles, California, ranging in ages of 6 to 14 years, were tested for physical working capacity ($PWC_{170}$). The test consisted of three consecutive workloads of six minutes in length for each workload at a pedalling rate of 60 to 90 rpm. The heart rates were recorded sthethoscopically at the fourth and sixth minute of exercise of each workload. The heart rates recorded were placed on a graph for each individual and the best fitting line was extrapolated to a heart rate of 170 bpm. The corresponding amount of work at a heart rate of 170 bpm was taken as the $PWC_{170}$ value. For the male 10 year olds (N=9), the $PWC_{170}$ and $PWC_{170}$/kg body weight were 551 and 13.78, respectively. The weight and height of the 10 year old group were 145 cm and 40 kg, respectively. The $PWC_{170}$ (kpm/min) correlated with weight and height with r values of .81 and .83, respectively. Values of $PWC_{170}$ values (both kpm/min and kpm/kg/min) demonstrated a distinct increase with age.

The results showed that the $PWC_{170}$ values increased with age, height and weight. When the values were compared to the subsequent review (Adams etal., 1961) the differences between $PWC_{170}$ were found not to be significant. The conclusion drawn was that there are definite differences

existing in $PWC_{170}$ values between sexes and ages.

Adams et al. (1961) conducted a cross-sectional investigation on physical working capacity of male and female Swedish school children, aged 10, 11 and 12 years. One group numbering 102 was from a Stockholm city school and the other group, numbering 94, was from two country schools. Procedures were similar for determining $PWC_{170}$ values as in the Los Angeles study, except in this case, only two consecutive work-loads were given.

The mean $PWC_{170}$ value for the male 10 year olds from the city school was 490 kpm/min. When expressed in terms of body weight, the corresponding $PWC_{170}$ value was 13.61. The mean weight was 36 kg. The $PWC_{170}$ value for the male 10 year olds from the country school was 510 kpm/min. When expressed in terms of body weight, the corresponding $PWC_{170}$ value was 15.45. The mean weight was 33 kg. Results showed that the physical working capacity were greatest in the male groups as compared to the female group and that the $PWC_{170}$ values increased with age, expressed both in terms of kpm/min and kpm/kg/min. The differences between the country 10 year old $PWC_{170}$ means and city 10 year old $PWC_{170}$ means were not significant.

Cumming and Cumming (1963) conducted a single session test required to measure physical work capacity of 200 Winnipeg school children cross-sectionally. The sample, including males and females, ranged in age from 6 to 16 years. At a speed of 60-70 rpm, the subjects performed a $PWC_{170}$ test on a electronically braked bicycle ergometer. The test lasted a maximum of 18 minutes, where the intensity of exercise was increased at the sixth and twelfth minute of exercise. The corresponding heart rates at the sixth and twelfth minute of exercise were plotted to

the corresponding workload and extrapolated to determine a workload at a heart rate of 170 bpm.

For the 10 year olds (N=5), the $PWC_{170}$ values expressed as kpm/min and kpm/kg/min were 458 and 13.50, respectively. The mean height and weight were 139 cm and 34 kg, respectively. The results revealed that there was a gradual increment in mean $PWC_{170}$ values (kpm/min and kpm/kg/min) with increasing age and that the boys consistently scored higher than the girls throughout the entire age range. It was observed, however, that the eight year old group scored higher on the $PWC_{170}$ test than the other age groups, despite their inferior size as determined by height and weight.

Alderman (1968) examined the longitudinal changes in $PWC_{170}$ values over a one year period on two groups of boys and girls, aged 10 and 14 years, from the city of Edmonton, Alberta. The test involved a continuous bicycle ergometer ride at a speed of 60-70 rpm for a period of 12 minutes. Three four-minute workloads were given to the subjects and the heart rate was recorded at the fourth, eighth and twelfth minute of exercise. Normal graphic extrapolation procedures determined the $PWC_{170}$ of each individual. For the 10 year old boys (N=29), the mean $PWC_{170}$ value was 317 kpm/min. One year later (age 11), the value was 570 kpm/min. No mean weights were given for the different age groups. As a result, $PWC_{170}$ /kg could not be calculated. The conclusion was that $PWC_{170}$ increases are not just related to age but a function of age. It was also concluded that boys score higher on $PWC_{170}$ tests than do girls.

Howell and Macnab (1968) conducted an extensive nation-wide cross-sectional survey in 1967 to measure and assess the physical working

capacity of normal Canadian school-aged children. The children ranged in age from seven to 17 years (2107 male and female subjects). A continuous 12 minute, three workload bicycle ergometer test was employed. Heart rates were recorded every minute of exercise and the fourth, eighth and twelfth minute heart rates of the three corresponding increasing workloads were used to determine $PWC_{170}$ values. The values for the 10 year olds (N=101) were 427.1 $\pm$ 95.1 and 12.79 $\pm$ 2.23 for $PWC_{170}$ expressed in terms of kpm/min and kpm/kg/min, respectively. A continuous increase in mean $PWC_{170}$ (kpm/min) for each age group, from seven to 17 years, was observed in the male samples. For the females, a steady increment was observed to age 13 where after this age, a continuous decrease was observed. When $PWC_{170}$ was expressed in terms of body weight, the mean values across all ages, remained relatively unchanged. The mean values for the females were similar to age 12 where an obvious decreasing trend was observed after age 12.

Macek et al. (1971) conducted an investigation on two groups of children from Prague to determine their physical working capacities and to compare these results to previously obtained and reported international mean values. The first group consisted of 63 healthy boys and girls aged 8, 10, 12 and 14 years. The second group consisted of 45 boys and 45 girls, 12 years of age and 45 boys, 14 years of age. The $PWC_{170}$ test involved a five minute continuous bicycle ergometer ride on three subsequent days whereby on the first, second and third day a workload was given corresponding to one watt per kg body weight, two watts per kg body weight and 2.5 watts per kg body weight, respectively. $PWC_{170}$ was calculated by means of graphic extrapolation. The results for the 10 year old boys (N=34) were 451 (kpm/min) and 14 (kpm/kg/min). The mean height and weight of the 10 year olds were 138 cm and 32 kg,

respectively. In particular, the $PWC_{170}$ values increased with age. When these same values were expressed in terms of body weight, the values of $PWC_{170}$ remained relatively unchanged.

Baggley and Cumming (1972) studied the seasonal variations of endurance measures; physical working capacity and maximal oxygen consumption, of elementary and high school students during a school year (10 months). Of particular concern are results observed on the elementary school-aged children. They included an entire elementary school class (10 boys and 14 girls) ranging in age from nine to 12 years. The mean age as of September was 11. Expressed in absolute terms, the mean $PWC_{170}$ scores for the elementary boys increased progressively over the year from 569 kpm/min to 641 kpm/min. When expressed in terms of body weight, the relative mean $PWC_{170}$ scores remained virtually the same (15.8 to 16.4 kpm/kg/min).

In summary thus far, boys score higher than girls in terms of physical work capacity. The studies all agree that for boys, in particular, $PWC_{170}$ kpm/min increases with age. However, there are discrepancies between various studies in terms of $PWC_{170}$ values expressed in terms of body weight changing with age. Adams et al. (1961a), Adams et al. (1961b), Cumming and Cumming (1963) report that $PWC_{170}$ kpm/kg/min values increase with age in children. Contrary to this, Howell and Macnab (1968), Macek (1971) and Baggley and Cumming (1972) find that $PWC_{170}$ kpm/kg/min values remain virtually unchanged during growth in children. The discrepancy between studies in regards to this phenomenon may be attributed to varying testing techniques or developmental peculiarities of the young population. It is also plausible that the discrepancies may be due to the levels of athletic activity specific

to each population. This phenomenon is discussed in subsequent paragraphs.

Cunningham and Eynon (1973) assessed the $\dot{V}O_2$ max and physical working capacity ($PWC_{170}$) of a cross-sectional group of well-trained boys and girls engaged in competitive swimming. In addition, the results of the swimmers were compared to age matched data from the total population and with adult swimmers. Nineteen boys (11.65 to 16.00 yrs) and 24 girls (10 to 15.41 yrs) were randomly selected from 112 competitive swimmers involved in 50 Ontario competitive swimming teams. Four adult swimmers from the University of Western Ontario swim team were also tested. The $PWC_{170}$ test was the same as used in the present investigation except a heavy weight pendulum was used. $\dot{V}O_2$ max was determined by a direct method while riding a bicycle ergometer.

The male swimmers were divided into four groups according to age: 11 years(N=10), 13 years (N=6), 14 years (N=8) and 21 years (N=4). The mean $PWC_{170}$ (kpm/min) values increased significantly as age increased, however, the $PWC_{170}$ (kpm/kg/min) values remained relatively constant between the age groups. The mean $PWC_{170}$ values of the 11 year old group expressed in terms of both kpm/min and kpm/kg/min were $851 \pm 232$ and $20.52 \pm 3.73$, respectively. It was noted that this group scored higher than the 14 and 21 year old groups when expressed per kg body weight and was slightly below the 13 year old group. When the $PWC_{170}$ values were compared to age matched children not actively engaged in athletic training, the swimmers scored substantially higher.

The results indicated that children of younger ages, who are actively involved in intensive physical training programs, score similarly to adult trained populations in terms of physical working capacity when the

influence of body weight is removed. It was also tenable that intensive training can improve physical work capacity in younger populations more so than what can be explained by increases of body size in normal populations.

In a study conducted by Daniels and Oldridge (1971) the oxygen consumption changes of young boys during growth and running training were observed. Fourteen boys (10 to 15 years) were measured for $\dot{V}O_2$ max and $\dot{V}O_2$ at submaximal running speeds at six month intervals over a total period of 22 months. Results demonstrated that $\dot{V}O_2$ max, expressed in terms of body weight, did not significantly change over the 22 month period. The body weight increases due to normal growth offset the increases in $\dot{V}O_2$ max l/min. There was, however, a significant decrease in $\dot{V}O_2$ per kg of body weight at submaximal running speeds. This latter phenomenon was attributed to improvement in running efficiency at submaximal speeds. They also felt that the decrease of $\dot{V}O_2$ per kg was more a function of growth rather than training.

Stewart and Gutin (1976) conducted an investigation to determine the effects of a physical training program on the cardiorespiratory fitness in children. The sample consisted of 24 normal healthy boys aged 10 to 12 years. Subjects were randomly divided into two groups - a training group (N=13) and a control group (N=11). The training group participated in an eight week program of interval training, where subjects ran four times a week. The training program consisted of both paced and all-out runs of either one minute or three minute duration. In the first week, each subject performed five repetitions of a paced run of one minute in length, five repetitions of an all-out run of one minute duration, three repetitions of a paced run of three

minute duration and three repetitions of an all-out run of three minute duration. Each subject performed one of the aforementioned training regimes each training session. As a result, a subject performed all of the aforementioned training regimes in a week since they trained four times a week. After the first week, one extra repetition was added to the one minute runs every two weeks and one extra repetition was added to the three minute runs two weeks later where no further repetitions were added. Training heart rates were telemetried on random subjects. Heart rates were observed approximating 185 bpm. This represented 90% of the mean maximal heart rate of 207 bpm. The control group performed low keyed activity games and mild stretching during the eight week period, four times a week.

Subjects were tested for $\dot{V}O_2$ max at pre-training and post-training on a motor driven treadmill. Pre-training and post-training heart rates and $\dot{V}O_2$ were determined on a bicycle ergometer at a workload of 300 kpm.

The results showed no significant difference between groups and no change occurred with training in respect to $\dot{V}O_2$ max and $\dot{V}O_2$ at submaximal bicycle riding. At pre-training testing, no significant difference was found between groups in respect to submaximal heart rates on the bicycle ergometer, however, the trained group demonstrated significant decreases in submaximal heart rates after training. The control group remained unchanged in respect to submaximal heart rates. Submaximal heart rates on the treadmill were also significantly lowered after training in respect to the trained group.

They concluded that the apparent main effect of short-term physical training in children is to improve submaximal cardiorespiratory functions that are independent of changes at maximal efforts.

Weber et al. (1976) found that with four sets of 10 year old twins, one twin training for 10 weeks and the other not training, the trained twin group improved their mean $\dot{V}O_2$ max by 23.5% while the untrained twinc group improved their mean $\dot{V}O_2$ max by 11.8%. This difference in improvement was significant at the .05 level.

Sprynarova (1974) followed the development of the functional capacity in a group of boys 11 to 18 years of age by measuring their $\dot{V}O_2$ max annually. A total of 139 boys were initially utilized in the study. Over the course of seven years, 100 subjects dropped out leaving 39 18 year old subjects left to test. The subjects were split up into three groups at age 11. One group was regularly trained, another trained not regularly, and the third group acted as untrained control group. Training involved active participation in basketball and track and field.

The results showed that increases of $\dot{V}O_2$ max l/min and $\dot{V}O_2$ max ml/kg/min occur during growth. It was also found that individuals who train more regularly can improve their aerobic power more so than individuals who train not as regularly or not at all.

By changing the amount the groups trained after age 15, it was found that the boys who trained regularly were able to achieve greater relative maximum oxygen uptakes during puberty despite the fact that the amount of training was greater after age 15 years. It was also found that the high levels of aerobic power obtained during puberty requires less training to achieve than to maintain thereafter.

Cumming et al (1967) measured the maximal oxygen consumption and pulse rate at a constant submaximal workload of six boys and six girls, 13 to 16 years of age. Measurements were taken on the first, second,

third, fourth, and sixth day of a one week intensive training program at a Manitoba youth camp using a bicycle ergometer. The results of the mean $\dot{V}O_2$ max values of all subjects did not significantly change over the course of one week. The corresponding mean maximal heart rate, however, did significantly decrease in both boys and girls by the end of the week. There was a tendency for mean submaximal pulse rate, at a constant work-load, to decrease over the week for the girls, however, the decrease was not significant. For the boys, a statistically significant decrease of mean submaximal heart rate was observed over the course of a week. They conclude that the decrease in the mean submaximal heart rate was likely due to physical training. However, they do state that lessened anxiety and improved mechanical efficiency are factors that can not be entirely excluded. They also conclude that a one week strenuous training regime on already fit subjects does not allow enough time to improve maximal aerobic powers.

Ekblom (1969) found that with six months of training, increases in $\dot{V}O_2$ max l/min and $\dot{V}O_2$ max ml/kg/min are observed in 11 year old children as compared to untrained 11 year children. The increases were of a 15% and 10% magnitude, respectively. Smaller gains were observed for submaximal heart rates in response to workloads of 300 and 450 kpm (approximately 5% gain at both workloads). The control group's $\dot{V}O_2$ max/kg body weight remained virtually unchanged over a six month period. The control group's submaximal heart rates increased slightly (approximately 3% gain at both workloads).

Andersen et al. (1974) investigated the physical performance capacity of 83 boys and 88 girls who attended school in the community of Lom, Norway. A combination of longitudinal and cross-sectional

techniques were employed. The primary purpose of this particular investigation was to see how maximal aerobic power is related to age, sex and development and morphological variables. When absolute values of $\dot{V}O_2$ max l/min are matched to age, the relationship is not linear where the slope of the line gradually increases at age 10 and increases sharply at age 14. The boys scored significantly higher than the girls at all ages. In terms of height, weight and lean body weight, for both boys and girls, the relationship to $\dot{V}O_2$ l/min is linear. The boys' slope is greater than the girls.

In a subsequent study by Andersen et al. (1974), where the same subjects were utilized, the relationship of heart rate and oxygen pulse to submaximal exercises served as the primary purpose. It was found that submaximal exercise heart rates are age and sex dependent during growth. The heart rates for both boys and girls decreased with age at absolute oxygen uptakes. The boys' submaximal heart rates to a given workload were lower than the girls at all ages. When submaximal heart rates are expressed as percentages of maximum and the same relative loads are applied to boys and girls, the age and sex differences disappear. Oxygen pulse increases with age at submaximal and maximal work for boys and girls. The boys score significantly higher than girls. In particular, boys exhibit linear increases of maximal oxygen pulse to age 12 years, where at that point it increases out of proportion to age. The investigators state that assuming that the arterio-venous-oxygen difference is unrelated to age and sex during growth, the changes in oxygen pulse at both submaximal and maximal work reflects the variation in stroke volume. As a result, they conclude that considering the relationship between body weight and oxygen pulse is linear, growth in heart

functional dimensions take place at the same rate as growth in body weight.

In a final investigation dealing with children of the Lom community, Andersen et al. (1976) observed the influence of an improved physical education program on the rates of growth of $\dot{V}O_2$ max. They found that the development of maximal aerobic power outbalanced the growth in body size. This was evidenced by increases of $\dot{V}O_2$ max expressed in terms of body weight and lean body mass with age. This was found to be contradictory to a cross-sectional study of children in the same community. Although they concluded that insufficient information was available to accurately assess the causes and mechanisms involved in increased fitness, they hypothesized that changes in fitness may be due to changes in habitual physical activity.

Bouchard et al. (1977) related submaximal working capacity to heart and body size of 237 boys, 8-18 years of age. They found that heart size and heart volume increased significantly with age. They also found that at a given age, body weight and body size are positively correlated with heart volume. Weight exhibited twice as much common variance with heart volume than height. The physical work capacity and $\dot{V}O_2$ both expressed at a heart rate of 130 bpm, significantly increase with age. It was also indicated that age, height and weight are highly correlated with submaximal working capacity. This has been substantiated by others (Adams et al., 1961; Gadhoke and Jones, 1969). Body height contributed less to the variance of submaximal working capacity than did either age or body weight. It was also found that, regardless of the age and size of a subject, the size of the heart still contributes significantly to submaximal working capacity, though the combination of

the variables produces a multiple correlation of .864 with submaximal working capacity. In conclusion, they also suggested that changes in the oxidative capacities of the muscle cell contribute to improved submaximal working capacities with age.

Andrew et al. (1972) investigated the heart and lung functions of competitive swimmers during growth. The swimmers were compared to children who were not actively engaged in an organized year-round athletic activity. The study was conducted on boys from age 8 to 17 years longitudinally. Of particular interest is the finding that the stroke volumes of the swimmers were not greater than the stroke volumes of the non-athletes. It was concluded that the larger stroke volume in association with a larger heart volume, as is characteristic of adult athletes, is not apparent until post-pubertal years.

Eriksson et al. (1973), utilizing thirteen 11 to 13 year old boys, observed the effects of training on muscle metabolism and enzyme activities. They also determined the effects of training on $\dot{V}O_2$ max. The 13 boys were divided into two groups. Group 1 (N=8) trained for four months and Group 2 (N=5) trained for six weeks. Group 1 trained three times a week consisting of interval work, calisthenics and basketball or soccer per workout. Each workout lasted approximately 60 minutes. Group 2 trained three times a week on a bicycle ergometer at high workloads representing 70% of maximal work. The total bicycle ride lasted a mean time of 30 minutes.

The results indicated a 19% increase and a 6% increase in $\dot{V}O_2$ max in Group 1 and Group 2, respectively. When $\dot{V}O_2$ max was expressed in terms of body weight, the increase in group 2 was very small. While the increase in group 1 was not as great as compared to $\dot{V}O_2$ max l/min, it

still indicated a 14% increase. The maximum arterio-venous oxygen difference did not change with training. As a result, the 14% increase in $\dot{V}O_2$ max ml/kg/min was entirely due to the increase in maximal oxygen transport. It was found that a pronounced increase in stroke volume occurred over four months of training. They concluded that the entire increase in the boys' $\dot{V}O_2$ max was a result of increased stroke volume. In adults, quite the opposite is found, where after a short period of training, increases in $\dot{V}O_2$ max resulted from increases in maximal arterio-venous oxygen differences.

Thus far, it is apparent that discrepancies exist among investigators as to whether or not exercise training elicits improvements in the aerobic fitness of children. Relevant to this point, some studies have shown that the intensity of exercise is the most important factor influencing cardiorespiratory changes due to training (Durnin et al.,1960; Wenger & Macnab,1975). Other studies have purported that the duration of exercise is the key (Jackson et al., 1968; Macnab et al., 1969; Sharkey, 1970). In light of this, Massicotte and Macnab (1974) attempted to relate the intensity of training to cardiorespiratory adaptations in children. Thirty-six boys, between 11 to 13 years of age, were matched on initial fitness. Three blocks were formed, of 12 subjects each. Subjects within a particular block were similar in terms of $\dot{V}O_2$ max. From the three blocks, subjects were randomly assigned to four training intensity programs. There were nine subjects in each treatment group consisting of three subjects from each of the three blocks. Treatment 1 group trained at a heart rate level of 170-180 bpm. Treatment 2 group trained at a heart rate level of 150-160 bpm. Treatment 3 group trained at a heart rate level of 130-140 bpm. Treatment 4 group acted as a

control and did not train. Training was performed on a bicycle ergometer of 12 minutes in length, 3 times a week.

Results indicated that submaximal mean heart rates, at workloads of 450 kpm/min and 600 kpm/min, significantly decreased in the three training groups. The control group's submaximal mean heart rate did not significantly change. The treatment 1 group (trained at 170-180 bpm) was the only group to significantly increase $\dot{V}O_2$ max ml/kg/min. An increase of 11% was observed. The investigators suggest that for short training sessions, the training stimulus should correspond to approximately 75% of the difference between resting and maximum heart rates in order to improve the aerobic capacity of children.

The findings of Massicotte and Macnab shed some light on why discrepancies exist among investigators who examine cardio-respiratory alterations in children as a result of training. Some of the investigations thus far reviewed find no increase in the aerobic fitness of children, when expressed in terms of body weight, with training. In those studies showing no change with training, the intensity of exercise may not have been sufficient to elicit a training effect. It is also plausible that the children who did not improve as a result of training were initially in very good aerobic condition at the onset of the training program. As a result, these children would have a lower potential for change.

The review of the related literature also shows that the aerobic fitness of highly trained children reach similar values of trained adults when the influence of body weight is removed.

Literature specifically related to hockey

The effects of competitive ice hockey on the physiological processes of adult man has been investigated (Seliger et al., 1972; Green and Houston, 1975; Green et al., 1976; Houston and Green, 1976). The results of these studies conclusively concur that the performance of a game of ice hockey requires a substantial contribution from the anaerobic processes. However, they also concur that because of the intermittent nature of the game, high requirements of the aerobic metabolism are required to facilitate recovery from the intermittent work bouts. Green et al. (1976) found that during a game of ice hockey, players demonstrate an incomplete recovery between shifts. It was suggested that hockey players should not only train their anaerobic capacities but also their aerobic powers as well. This in turn may help improve hockey performance throughout the entirity of the hockey game.

To this investigator's knowledge, only three studies have been conducted dealing with aerobic capacities of children who are actively engaged in the sport of ice hockey (Cunningham et al., 1976; Hamilton and Andrew, 1976; Shkhvatsabaya, 1977). These articles are reviewed subsequently.

In a study by Shkhvatsabaya (1977), the physical working capacity of young ice hockey players were measured. A total of seventy-seven boys were divided into three groups based on hockey history and age. Group 1 (N=26) made up of 11 year olds, regularly trained and played in ice hockey schools of Moscow for two to three years. Group 2 (N=27) were 12 year olds and regularly trained and played in ice hockey schools for four to five years. Group 3 (N=24) were 13 year olds and regularly trained and played in ice hockey schools of Moscow for five to six years.

All subjects, on an average, trained two hours daily, four times a week. They ran cross-country once a week.

The subjects of each group were tested for $PWC_{170}$. The test conducted was not continuous in nature, as it allowed the subject to rest for three minutes between the two workloads of five minutes in length. Graphic extrapolation was not used to calculate $PWC_{170}$ but a devised formula was utilized.

The results were as follows: group 1, 505.2 $\pm$ 18.56 kpm/min and 15.0 $\pm$ 0.49 kpm/kg/min; group 2, 663.0 $\pm$ 32.5 kpm/min and 15.6 $\pm$ 0.62 kpm/kg/min; and group 3, 795 $\pm$ 33.1 kpm/min and 16.36 $\pm$ 0.22 kpm/kg/min. It was noted that individual $PWC_{170}$ values varied within wide ranges at each respective group.

These findings were found to be greatly superior to values of age-matched non-trained Russian children. The results expressed in kpm/kg/min were similar to results obtained on non-trained adult men. In fact, for group 3, the results matched those obtained by top Russian athletes. Adult values were not presented.

Differences of mean $PWC_{170}$ kpm/min between each group were significant. The differences of mean $PWC_{170}$ kpm/kg/min between each group were smaller although the older groups obtained higher means. No values of significance were given. In conclusion, Shkhvatsabaya states that the differences between the groups, based on $PWC_{170}$, are not only caused by increases in age and body size, but also, previous training, in varying degrees.

Hamilton and Andrew (1976) investigated the influence of growth and athletic training on heart and lung functions in 52 boys, of which 25 were engaged in competitive ice hockey. Five groups were established

as follows: group 1 (N=12) competed on an all-star hockey team for 28 weeks (age $\overline{X}$ = 12.7 yr; ht $\overline{X}$ = 150.9 cm; wt $\overline{X}$ = 41.4 kg); group 2 (N=10) acted as a pre-pubertal control group and were not engaged in any rigorous training regime for at least one year prior to testing (age $\overline{X}$ = 12.4 yr; ht $\overline{X}$ = 152.9 cm; wt $\overline{X}$ = 41.4 kg); group 3 (N=13) competed on an all-star ice hockey team for 28 weeks (age $\overline{X}$ = 16.8 yr; ht $\overline{X}$ = 177.0 cm; wt $\overline{X}$ = 70.8 kg); group 4 (N= 11) acted as a post-pubertal control group and were not engaged in any rigorous training regime for at least one year prior to testing (age $\overline{X}$ = 16.6 yr; ht $\overline{X}$ = 169.0 cm; wt $\overline{X}$ = 56.0 kg); group 5 (N=6) matched an age, height and weight to post-pubertal hockey group and were chronically active in a regular strenuous physical training program (age $\overline{X}$ = 17.1 yrs; ht $\overline{X}$ = 180.7 cm; wt $\overline{X}$ = 72.8 kg).

Subjects were tested on a number of cardio-pulmonary variables, two of which included submaximal heart rates and stroke volume at varying workloads on a bicycle ergometer.

Results showed that the post-pubertal hockey group could perform workloads at significantly lower heart rates and significantly larger stroke volumes as compared to the two post-pubertal control groups. In turn, the non-hockey trained post-pubertal group produced lower heart rates and larger stroke volumes as compared to the untrained post-pubertal control group. This finding was found to be consistent with current knowledge regarding the effects of training on the physically mature individual.

When comparing submaximal heart rates and stroke volumes between the two pre-pubertal groups, the differences were non-significant. Considering the intensity in which the pre-pubertal hockey group trained,

Hamilton and Andrew concluded that the lack of notable difference could be due to an innate high degree of physical activity in the pre-pubertal control group. They also express the possibility that the hockey training program was of neither sufficient intensity nor duration to successfully elicit improvements in the measured functions.

They also raised the point that the observable differences between post-pubertal groups may be a result of a training process experienced by the trained group or relative detraining of the untrained group. The findings, however, do suggest that involvement in competitive ice hockey during the growth period of adolescence may enhance the oxygen delivery system.

Cunningham et al (1976) measured the cardiopulmonary capacities of 15 selected 10 year old hockey players. The boys had been involved in organized hockey for some four years, three of which had been spent in a competitive league. The team had placed third in Western Ontario at the end of the 1971-72 season. The subjects were tested for hemoglobin content, $PWC_{170}$, and $\dot{V}O_2$ max. The bike test involved three workloads of five minutes in length at a speed of 50 rpm. This was a discontinuous work capacity test.

The mean age, height and weight were 10.6 years, 140.5 $\pm$ 5.6 cm and 35.5 $\pm$ 5.4 kg, respectively. The mean $PWC_{170}$ values were 510 $\pm$ 83 kpm/min and 14.55 $\pm$ 2.48 kpm/kg/min. The mean value for $PWC_{170}$ and $PWC_{170}$ per body weight was ranked at the 83rd and 79th percentiles, respectively, when compared to norms for Canadian children (Howell and Macnab, 1968). In regards to the height and weight variables, the investigators concluded that since the young hockey players were similar to heights and weights for Canadian boys of similar age, their ability to excel in hockey must result from other factors.

On the basis of the physical work capacity results, the investigators found that the functional capacity of the cardiovascular system of young athletes appeared to be similar to that of mature, highly successful athletes involved in competitive ice hockey.

Hockey skill tests

The bulk of studies concerned with the sport of ice hockey have been conducted with the purpose in mind of evaluating hockey players based on a number of hockey test items, and in turn, measuring the reliability, validity, and predictability of the test variables (DiVincenzo et al., 1960; Alexander et al., 1963; Doroschuk and Marcotte, 1965; Hache, 1967; Merrifield and Walford, 1969; Hansen et al., 1970; Merrifield and Walford, 1971; Jobin, 1975; Laviviere et al., 1976).

The subsequent articles primarily deal with investigations that observe scores on hockey skill tests which are pertinent to the present investigation.

Turcotte (1978) conducted a longitudinal study investigating the influence of competitive ice hockey on boys 8 to 11 years old. This particular study included the two hockey teams currently serving as samples in the present investigation. The variables that the boys were tested on were the same as those in the present investigation. His conclusion drawn, was that hockey players who engage in intense programs of ice hockey are capable of demonstrating fitness levels and hockey skill levels superior to other age-matched counterparts.

Turcotte also investigated the effects of lay-off on the performance times of ice hockey skill tests. He found no apparent effect. He found, in fact, that in many cases the performance times improved after lay-off. He attributed this phenomenon to either growth or hockey

clinics the subjects were involved in during the summer months.

In a study conducted by Hansen et al. (1970), 195 subjects participating in the Point Claire Hockey School were tested on a number of hockey tests. Of these tests, the forward speed skate, the backward speed skate, modified Marcotte's puck control skate and the Hansen's modified puck control skate, were the same as used in the present investigation. The subjects were divided into teams according to age. Correlations were calculated between test items. It was found that the three distances of the forward speed skate correlated with one another highly in all teams. Correlation coefficients ranged from .53 to .87. Most correlation coefficients were higher than .75. In the backward speed skate, the correlations between the three distances for all teams were very high, eanging in r values from .93 to .98. Low to moderate correlations were obtained when the agility skates were compared to the forward and backward speed skates. Similar correlations were observed when the modified Marcotte's puck control test was compared to both forward and backward speed skates. Most r's ranged from .40 to .75. Low correlations were observed when the Hansen's modified puck control test was compared to the forward speed skate where most r's ranged from .20 to .45 for all teams. Higher correlations were obtained when the Hansen test was compared to the backward speed skate. These were similar to the Marcotte's test comparisons. The modified Marcotte's puck control skate correlated with the Hansen's modified puck control skate at an r value of .84. The two puck control skates were highly reliable. As results indicated, Hansen referred to the three distances of the forward speed skate as follows: 60 ft, acceleration phase; 60-90 ft, speed phase; and 90-120 ft, deceleration phase. For the backward speed

skate, the initial 90 ft was referred to as acceleration phase and the 90-120 ft phase was referred to as the speed phase. The investigators found that the 120 ft forward speed skate consistently predicted the 90 ft distance and the 90 ft distance consistently predicted the 60 ft distance. Similar results were obtained on the backward speed skate, although these correlations were closer than those of the forward speed skate. In all cases, the reliability coefficients were high.

Hansen recommended that the 120 ft backward and forward speed skate be used to measure linear speed for hockey players except for the mosquitos (age approximately eight years), where the 90 ft backward and forward speed skate is recommended.

The validity coefficients that were significant, as obtained from correlations between ranking of experts and actual measurements for each test, were as follows: forward speed skating 90 and 120 ft, 0.58; backward speed skating 90 ft, 0.66 and 120 ft, 0.62; modified Marcotte puck control, 0.63; and Hansen's modified puck control, 0.51.

Jobin (1975) attempted to predict "in vivo" hockey performance from the results obtained on a number of non-specific hockey variables and specific hockey variables. A sample of fourteen boys (age 8 yrs) were utilized. This was the same team as the Mite $A_1$ team of the present investigation, only two years younger. The multiple regression equations developed using a number of combinations of variables to predict "in vivo" hockey performance were all poor. Jobin concluded that the inability to predict "in vivo" hockey performance (as evaluated by the coaches) was due to the homogeneity of the sample and not due to a non-existant relationship of the variables to "in vivo" hockey performance.

DiVincenzo et al. (1960) formulated an instrument to predict hockey

performance using 148 secondary school boys as subjects. Four skill tests were ultimately selected as being significant factors in the performance of ice hockey. They were: shooting for accuracy, agility, stick handling and speed. The correlations developed by comparing the ranking of 10 teams from results on the tests, to the coaches' subjective ranking of hockey ability, ranged from .11 to .75 (2 r's were .11 and .14, while the rest ranged from .45 to .74). The conclusion of the study was that the tests needed further validation, since the correlations between the instrument ranking and coaches' ranking were widely ranged, inconclusive and in many case, low.

Merrifield and Walford (1970), using fifteen male college students of the Ithaca College Hockey Club, developed six hockey tests for the purpose of measuring selected basic skills in ice hockey. The tests included forward speed skating (120 ft), backward speed skating (120 ft), skating agility, puck carry, shooting and passing. The reliabilities for the forward speed skate, backward speed skate, agility skate and puck carry were .74, .80, .94 and .93, respectively. The shoorting and passing tests received low reliabilities and were not considered for further investigation. The validity coefficients obtained by comparing test results to the ranking by the hockey coach on playing ability were as follows: forward skate, .74; backward skate, .80; agility skate, .94; and puck carry, .93 (all significant at .01 level). The backward speed skate and agility skate correlated poorly with the forward speed skate. Other intercorrelations were all found to be significant at the .05 level, except for skating agility vs backward speed skating, where the .91 r value was significant at the .01 level. The latter comparison indicated that they are measuring approximately the same element, since the agility

skate involved some backward skating.

It was concluded that an ice hockey test battery should include forward speed skating, a puck carrying test, and either a backward speed skate or agility skate.

The Illinois agility run was adapted for use on ice and administered to twenty-seven subjects by Doroschuk and Marcotte (1965). The subjects ranged in age from 18 to 25 years. When the results of the test were compared to the instructor's subjective evaluation of hockey ability, a .83 correlation coefficient was observed. The reliability coefficient on test-retest for the same group was .93. It was concluded that this test could be used as a screening device to objectively and efficiently rate hockey players at initial team try-outs. It could also be used as a short objective test for hockey ability.

## METHODS AND PROCEDURES

### Subjects

Twenty-eight normal healthy pre-adolescent boys, aged 10 years, were chosen to serve as subjects for the purpose of this study. All twenty-eight boys competed in the sport of hockey. Fourteen of the boys played on a Mite 'A' team and fourteen of the boys played on a Mite 'B' team. For the purpose of this study, one team will be referred to as the Mite $A_1$ team and the other as the Mite $B_1$ team. Both teams competed within their respective mite league in the "Edmonton Minor Hockey League". Both teams represented the Malmo Community and all twenty-eight subjects resided within the boundaries of the community.

The Mite $A_1$ team played approximately sixty games, including league, tournament and exhibition games, over the period of four months, December, 1975 through March, 1976. They practiced twice a week.

The Mite $B_1$ team played approximately 25 games, including league or otherwise games over the same period of four months. They practiced once a week.

Team members from both teams were encouraged to skate as frequently as possible during the season.

### Experimental Design

The selection of the team members to either the Mite $A_1$ team or the Mite $B_1$ team was conducted by the appropriate team's coaches. The fourteen subjects displaying superior general hockey ability, in team try-outs, were selected to the Mite $A_1$ team. The procedure of team

selection was not controlled or influenced in any way by this investigator. Selection was based strictly on the appropriate team's coaches' perception of hockey proficiency.

It was presumed that individuals playing in the Mite A city hockey league would be confronted with a more physically demanding hockey game as compared to those individuals competing in the Mite B division. It was also presumed that superior hockey skill executions would be required to compete in the Mite A division.

Playing members of the Mite $A_1$ and Mite $B_1$ teams were tested on a number of occasions and on a number of physical and performance variables. Subjects were tested pre- and post-season for hockey proficiency. Subjects were also tested at post-season for physical working capacity, general fitness performance, strength and body size.

## Testing Conditions

Subjects were tested for hockey proficiency on October 10, 1975 (pre-season) and February 26, 1976 (post-season). Testing was conducted in the University of Alberta Indoor Ice Arena. The ice and temperature conditions were the same for both testing dates.

Subjects were tested on a number of fitness performance items on May 26, 1976. Testing was conducted in the University of Alberta Main Gymnasium. On the same day, height and weight were measured and recorded. Height and weight measures were obtained prior to fitness performance testing.

Measurements of grip strength and physical work capacity were obtained on May 1, 1976. Both tests were conducted at the Malmo Community Centre. The grip strength test was performed prior to the physical work capacity test for all individuals.

Measurement of hockey proficiency

The individual subjects of each team performed a number of hockey tests at pre- and post-season according to the procedure outlined by Hansen (1970). The battery of tests included a forward and backward speed skate, a forward agility skate and two puck control skates. An additional test measuring backward agility was included according to the procedure of Gill (1977). An explanation of each test follows. The two agility skates and puck control skates are diagramatically presented in Figure 1.

1) Forward Speed Skate (60', 90', 120'): From a skating start of 10 feet, subjects skatedas fast as possible across the goal line and pastthree cones which were set linearly at 60, 90 and 120 foot distances from the goal line. Subjects skated in pairs, whereby the farthest from the timers acted as motivators. Timers were located at each pylon. The stop watches started as the test subject reached the ten foot line (goal line).

2) Backward Speed Skate (60', 90', 120'): The procedure in this test was exactly the same as the forward skate but performed skating backwards.

3) Modified Marcotte's Puck Control Test: The subject started at the goal line with a puck on his stick and both skates on the line. He then skated out as far as the first cone, changed directions, skated back, weaved through the cones on the ice and sprinted back to the finish line with the puck.

4) Hansen's Modified Puck Control Test: From a standing start, the subject kicked a puck ahead to his stick from the blue line and skated around the first cone in a counter-clockwise direction. He

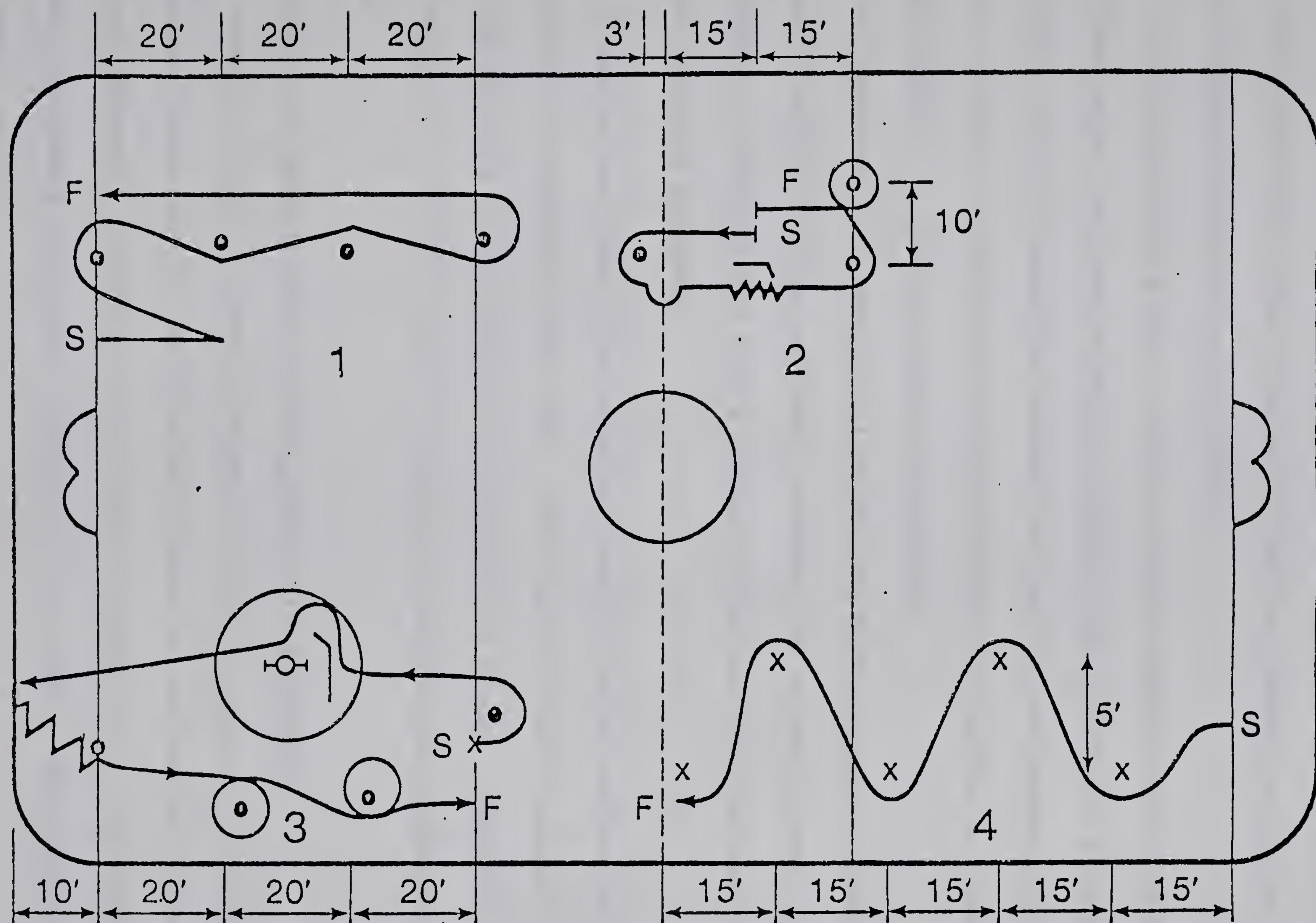


Figure 1. Diagramatic presentation of the puck control and agility skates 1) Modified Marcotte's Puck Control Skate; 2) Agility Skate; 3) Hansen's Modified Puck Control Skate; 4) Macnab-Gill Backward Agility Skate

then skated towards the stick and jumped over it while handling the puck and proceeded to the boards. At this point he stopped, then skated backwards to the goal line, turned to forward and proceeded with the puck around the first pylon (clockwise) and then around the second pylon (counter-clockwise) to the finish.

5) Skating Agility Test: From a standing position with his back to the first pylon, the subject skated backwards and pivoted to forward at the pylon. He then jumped the center line and ran the length of the stick. He then did tight turns around the other two pylons and skated to the finish. No puck was used in this test.

6) Macnab-Gill Backward Skating Agility Test: Subjects skated through five pylons using backward crossovers for a total linear distance of 75 feet. The start was from a standing position with the back to the pylons. No puck was used.

A warm-up was given prior to actual testing and an explanation and demonstration accompanied each test. The time required to complete each test was recorded to the nearest once-tenth of a second. Mistrials were repeated. Subjects wore full equipment and carried sticks in all tests.

Measurement of general motor ability and physical fitness

The C.A.H.P.E.R. Fitness Performance Test was employed to measure the general motor ability and physical fitness of each subject. The test was conducted according to the method as described in the CAHPER fitness performance test manual (Hayden et al., 1966). The performance test consisted of:

1) 50 yard dash - From a standing or crouched position the subjects ran a 50 yard straight sprint in pairs. On the starter's signal

("ready, go") which was the brisk downward motion of his extended arm, the timers started the stop watches and they were stopped when any part of the body crossed the finish line. Both subjects were monitored and times were recorded to the nearest tenth of a second.

2) 300 yard run - The 300 yard run was conducted using the same criterion and method as the 50 yard dash. The course for this measure consisted of two pylons set 50 yards apart which was circled three times.

3) Shuttle run - On the starter's signal two subjects lying face down at the starting line ran to a point 30 feet away, picked up a block, returned to the starting line, placed the block behind the starting line, returned and picked up the second block, then sprinted straight through the finish line. Criterion and times were recorded as in the previous two runs. Two trials, with a rest between trials, were given with the best time for each subject being recorded.

4) Speed sit-ups - To perform the sit-ups subjects laid on a mat with their hands clasped behind their heads and knees bent. A partner held the feet down on the mat while the subject performed his sit-ups. On the starter's signal, subjects began to perform the sit-ups touching their elbows to their knees and returning to a prone position on the mat. The subjects were asked to do as many of these sit-ups as they could in one minute. At the end of sixty seconds subjects were instructed to stop and their scores were recorded to the nearest complete execution of a sit-up.

5) Flexed arm hang - The subjects grasped a horizontal bar with palms towards the face. Help was given to each subject to lift him up to the bar. The subjects were instructed to keep their arms flexed so that the bar was at eye level at all times. A stop watch was used to

record, to the nearest second, the moment at which the subject could no longer hold this position. Only one trial was permitted and the test terminated when the subjects could no longer keep the bar at eye level.

6) Standing broad jump - The subjects began with their feet slightly apart and with their toes behind a starting line on the floor. Then, by bending their knees and ankles while swinging their arms, the subjects jumped as far as they could. Scorers marked the distance jumped from the starting line to the back of the nearest heel. The subjects were instructed to take off with their knees bent at an angle of 30 to 45 degrees. Two trials were given and the furthest jump was recorded to the nearest inch.

Motivation by encouragement was given to all subjects in all performance tests. Instructions on how to perform all the tests were given prior to the actual testing. Subjects wore gym shoes for all events and most of the subjects wore gym equipment.

Measurement of height and weight

Height was recorded to the nearest inch and converted to the nearest tenth of a centimeter. Weight was recorded to the nearest half pound and converted to kg. Measurements of height and weight were recorded on a medico-detecto scale. Shoes were removed for both measurements.

Measurement of grip strength

Grip strength was measured using a Stoelting adjustable hand grip dynamometer. The subject adjusted the handle to a comfortable position, and the tester demonstrated the technique to be used. The subject was instructed to begin with the dynamometer at shoulder height, with the arm extended out from the body, then squeezing the dynamometer as hard

as possible while bringing his arm down to his side. Each subject was given two trials with each hand and the best score for each hand recorded to the nearest .5 kilogram. Verbal encouragement was expressed during each test.

Measurement of physical work capacity

The $PWC_{170}$ test was employed according to Howell and Macnab (1968). A modified stationary bicycle ergometer (Monarch type) was used as described by Howell and Macnab (1968). The seat height was adjusted for each subject to suit leg length and comfort. The bicycle was calibrated immediately following all of the tests. The calibration constants are recorded in Appendix A.

The subjects pedalled for twelve minutes at sixty revolutions per minute. A pre-calibrated metronome was used to designate the rate of pedalling. Using a three-lead electrode system (Einthoven Triangle) and a Sanborn 500 Visio-Cardette Electrocardiogram, heart rates were recorded at rest and at the end of each minute of exercise. Pedal revolutions were also recorded following each minute of exercise, by a counter attached to the bicycle.

At the end of the fourth and eighth minute the workload was increased. The desired heart rate response to the three workloads (at the fourth, eighth and twelfth minute of exercise) were 115-130 bpm, 135-145 bpm, and 160-180 bpm, respectively.

Measurement of "in vivo" hockey performance

The two teams' respective coaches subjectively ranked all twenty-eight subjects (two teams grouped into one), from one to 28, based on hockey playing ability in actual game situations. The ranking occured at the latter part of the season.

Calculations

In order to calculate the physical working capacity at a heart rate of 170 bpm ($PWC_{170}$), the results necessary were fed into a computer program. The summary of the computer program is presented in Appendix B.

The age of the subjects were calculated as of March 26, 1976.

Means and standard deviations were calculated for the two teams on all the variables under concern.

Statistical analysis

Descriptive analyses were applied to the results of the pre- and post-season hockey tests. Means and standard deviations were calculated for the two teams at pre-season and at post-season. Differences in the means and standard deviations of the hockey tests at pre- and post-season between the two teams were calculated. Differences of the means and standard deviations, within teams, from pre- to post-season were calculated as well as differences in the rate of change.

T-tests for the differences of the means for independent samples were calculated between teams on height, weight, grip strength, CAHPER fitness performance test items, and $PWC_{170}$. A program available in the SPSS manual (1975) was utilized.

Pearson product moment correlation coefficients were calculated comparing all the test variables to one another. A program available in the SPSS manual was utilized. Both teams were grouped into one (N=28) for this analysis.

The final statistical analysis conducted was a multiple regression using stepwise procedures (SPSS, 1975) to predict "in vivo" hockey performance from the results of the hockey test items. For this

particular analysis, all the subjects from both teams were grouped into one (N=28) and ranked according to "in vivo" hockey performance.

This type of analysis combined standard multiple regression and stepwise procedures in a manner which provides considerable control over the inclusion of independent variables in the regression equation. Because of the low ratio existing between the number of independent variables and the sample size, care must be taken when interpreting the results. The SPSS manual suggests that when the existing ratio is low, the research goal should be entirely or primarily predictive and not explanatory.

The termination of the stepwise regression occured when the addition of a variable did not increase the multiple R value more than what would be expected by a single variable regression. In other words, if the $R^2$ change did not exceed the ratio of 1/25 or 4%, the stepwise analysis was terminated.

The generalized equation of the multiple regression model is:

$$\hat{y} = A + B_n X_1 + B_2 X_2 + \ldots . \; B_n X_n$$

where $\hat{y}$ = predicted y (y = criterion)

A = constant term or Y intercept

B = regression weight

X = predictor variable

# RESULTS

The names, identification numbers, and dates of birth of each individual subject are presented in Appendix C. The data are grouped according to a subject's representative team - either Team $A_1$ or Team $B_1$.

<u>Comparison of the teams based on age, height and weight</u>

Individual ages, heights and weights, for each team are presented in Appendix D. Comparisons of the means and standard deviations of age, height and weight for each team are presented in Table I.

In Table I, the average age of the Mite $A_1$ team was 10.84 $\pm$ 0.25 years, whereas the average age of the Mite $B_1$ team was 10.77 $\pm$ 0.25 years. A difference in mean age of .07 years resulted. This difference was found to be not significant ($p > .05$).

In regards to height the Mite $A_1$ team was taller by 1.47 cm as is depicted by heights of 144.02 $\pm$ 5.66 cm and 142.55 $\pm$ 4.11 cm for the Mite $A_1$ team and Mite $B_1$ team, respectively. This difference in height was not significant ($p > .05$).

The Mite $A_1$ team and Mite $B_1$ team obtained mean weights of 33.92 $\pm$ 4.72 kg and 33.64 $\pm$ 3.63 kg, respectively. Again, the Mite $A_1$ team proved to have the higher mean. Although the mean was higher by .28 kg, this difference was not significant ($p > .05$).

TABLE I COMPARISONS OF THE MITE $A_1$ AND MITE $B_1$ TEAM MEANS BASED ON AGE, HEIGHT AND WEIGHT

| VARIABLE | TEAM | N | MEAN | STANDARD DEVIATION | STANDARD ERROR | T VALUE | 2-TAIL PROBABILITY |
|---|---|---|---|---|---|---|---|
| Age (yrs) | Mite $A_1$ | 14 | 10.84 | 0.25 | 0.07 | -0.70 | 0.491 |
| | Mite $B_1$ | 14 | 10.77 | 0.25 | 0.07 | | |
| Height (cm) | Mite $A_1$ | 14 | 144.02 | 5.66 | 1.51 | -0.79 | 0.439 |
| | Mite $B_1$ | 14 | 142.55 | 4.11 | 1.10 | | |
| Weight (kg) | Mite $A_1$ | 14 | 33.92 | 4.72 | 1.26 | -0.17 | 0.866 |
| | Mite $B_1$ | 14 | 33.64 | 3.63 | 0.97 | | |

Comparison of the teams based on the battery of hockey tests at pre-season, post-season, and between pre- and post-season

Individual results of the hockey tests are presented in Appendix E grouped according to the individual's respective team. The data presented in Table II are a summary of the pre- and post-season mean scores and standard deviations which each team acquired in all of the hockey tests under investigation. On all of the hockey tests, the Mite $A_1$ team means were superior to those of the Mite $B_1$ team at both pre-season and post-season.

Pre-season comparisons. Upon observation of Table II, the Mite $A_1$ team demonstrates faster mean scores and smaller standard deviations than the Mite $B_1$ team on all of the hockey tests. In Table III, the differences between the means and standard deviations of the two teams at pre-season are presented.

In the Forward Speed Skate, the Mite $A_1$ team produced superior mean times by .35 secs, .23 secs and .63 secs at the 60, 90 and 120 foot intervals, respectively. The variances, as depicted by the standard deviations of the means were similar for both teams at the 60 and 90 foot intervals. The Mite $A_1$ team produced the smaller variances and resulted in differences from the Mite $B_1$ variances of .06 S.D. and .08 S.D. at the 60 and 90 foot marks, respectively. At the 120 foot mark, the difference in the variance was greater than the difference of the 60 and 90 foot marks. In this case, the Mite $A_1$ team produced a smaller variance by .21 S.D.

In the Backward Speed Skate, the Mite $A_1$ team means were faster by 1.07 secs, 1.30 secs, and 1.96 secs than the Mite $B_1$ team means in the 60, 90 and 120 foot marks, respectively. The differences in

TABLE II SUMMARY OF THE PRE- AND POST-SEASON MEANS AND STANDARD DEVIATIONS OF THE HOCKEY TESTS FOR THE MITE $A_1$ AND MITE $B_1$ TEAMS

| | | PRE-SEASON | | POST-SEASON | |
|---|---|---|---|---|---|
| | | MITE $A_1$ | MITE $B_1$ | MITE $A_1$ | MITE $B_1$ |
| Forward Speed Skate | 60' | 3.06 ± 0.17 | 3.41 ± 0.23 | 2.91 ± 0.10 | 3.01 ± 0.11 |
| | 90' | 4.58 ± 0.20 | 4.81 ± 0.28 | 4.19 ± 0.14 | 4.39 ± 0.17 |
| | 120' | 5.51 ± 0.16 | 6.14 ± 0.37 | 5.47 ± 0.18 | 5.66 ± 0.18 |
| Backward Speed Skate | 60' | 4.37 ± 0.32 | 5.44 ± 0.90 | 4.08 ± 0.28 | 4.60 ± 0.34 |
| | 90' | 6.39 ± 0.41 | 7.69 ± 1.35 | 5.86 ± 0.36 | 6.58 ± 0.51 |
| | 120' | 7.88 ± 0.51 | 9.84 ± 2.06 | 7.57 ± 0.47 | 8.51 ± 0.65 |
| Agility Skate | | 11.75 ± 0.74 | 13.03 ± 1.18 | 9.31 ± 0.33 | 10.42 ± 0.56 |
| Modified Marcotte's Puck Control Skate | | 16.44 ± 0.95 | 19.61 ± 2.38 | 15.09 ± 0.76 | 17.24 ± 0.77 |
| Hansen's Modified Puck Control Skate | | 21.35 ± 1.44 | 26.80 ± 3.16 | 19.33 ± 1.42 | 22.28 ± 1.26 |
| Macnab-Gill Backward Agility Skate | | 11.12 ± 0.53 | 14.88 ± 2.57 | 9.13 ± 0.46 | 11.19 ± 1.38 |

[a] Values are $\overline{X} \pm$ S.D.

[b] Means represented in seconds

TABLE III DIFFERENCES OF THE MEANS AND STANDARD DEVIATIONS OF THE HOCKEY TESTS BETWEEN THE MITE $A_1$ AND MITE $B_1$ TEAMS AT PRE-SEASON

| | | MITE $A_1$ MEAN | MITE $A_1$ S.D. | MITE $B_1$ MEAN | MITE $B_1$ S.D. | DIFFERENCES BETWEEN MEAN | DIFFERENCES BETWEEN S.D. |
|---|---|---|---|---|---|---|---|
| Forward Speed Skate | 60' | 3.06 | $\pm$ 0.17 | 3.41 | $\pm$ 0.23 | .35 | .06 |
| | 90' | 4.58 | $\pm$ 0.20 | 4.81 | $\pm$ 0.28 | .23 | .08 |
| | 120' | 5.51 | $\pm$ 0.16 | 6.14 | $\pm$ 0.37 | .63 | .21 |
| Backward Speed Skate | 60' | 4.37 | $\pm$ 0.32 | 5.44 | $\pm$ 0.90 | 1.07 | .58 |
| | 90' | 6.39 | $\pm$ 0.41 | 7.69 | $\pm$ 1.35 | 1.30 | .94 |
| | 120' | 7.88 | $\pm$ 0.51 | 9.84 | $\pm$ 2.06 | 1.96 | 1.55 |
| Agility Skate | | 11.75 | $\pm$ 0.74 | 13.03 | $\pm$ 1.18 | 1.28 | .44 |
| Modified Marcotte's Puck Control Skate | | 16.44 | $\pm$ 0.95 | 19.61 | $\pm$ 2.38 | 3.17 | 1.43 |
| Hansen's Modified Puck Control Skate | | 21.35 | $\pm$ 1.44 | 26.80 | $\pm$ 3.16 | 5.45 | 1.72 |
| Macnab-Gill Backward Agility Skate | | 11.12 | $\pm$ 0.53 | 14.88 | $\pm$ 2.57 | 3.76 | 2.04 |

Note: In all cases, the mean scores of the Mite $A_1$ team were higher and the variances of the Mite $A_1$ team, as depicted by S.D., were smaller.

[a]Mean represented in seconds

variances at the 60, 90 and 120 foot marks were greater in the backward speed skate as compared to the forward speed skate, whereby the Mite $B_1$ team demonstrated again the larger variances. The differences in variance were .58 S.D., .94 S.D. and 1.55 S.D. for the 60, 90, and 120 foot distances, respectively.

The results of the four remaining hockey skill tests demonstrates that the Mite $A_1$ team produced superior times as well as smaller respective variances. The differences between the means for the Agility Skate; the Modified Marcotte's Puck control test, the Hansen's Modified Puck Control test, and the Macnab-Gill Backward Agility skate were 1.28, 3.17, 5.45, and 3.76 secs, respectively. The differences between the variances for the respective tests were .44, 1.43, 1.72 and 2.04 S.D.

Post-season comparisons. Upon observation of Table II, the Mite $A_1$ team demonstrated faster mean scores and smaller standard deviations than the Mite $B_1$ team on all of the hockey tests. In Table IV, the differences between the means and standard deviations of the two teams at post-season are presented.

The Mite $A_1$ team produced superior mean times at the 60, 90 and 120 foot mark of the forward speed skate as compared to the Mite $B_1$ team. They had faster mean times by .10, .20, and .19 seconds at the 60, 90 and 120 foot marks, respectively. The variances, as depicted by the standard deviations of the means, were very similar for both teams at all three distances. The variance differences at the 60 and 90 foot distance between the two teams were .01 and .03 S.D., respectively, with the Mite $B_1$ team having the larger variances. At the 120 foot distance, the variances were the same.

In the Backward Speed Skate, at the 60, 90 and 120 foot marks,

TABLE IV DIFFERENCES OF THE MEANS AND STANDARD DEVIATIONS OF THE HOCKEY TESTS BETWEEN THE MITE $A_1$ AND MITE $B_1$ TEAMS AT POST-SEASON

| | | MITE $A_1$ MEAN | MITE $A_1$ S.D. | MITE $B_1$ MEAN | MITE $B_1$ S.D. | DIFFERENCES BETWEEN MEAN | DIFFERENCES BETWEEN S.D. |
|---|---|---|---|---|---|---|---|
| Forward Speed Skate | 60' | 2.91 | ± 0.10 | 3.01 | ± 0.11 | .10 | .01 |
| | 90' | 4.19 | ± 0.14 | 4.39 | ± 0.17 | .20 | .03 |
| | 120' | 5.47 | ± 0.18 | 5.66 | ± 0.18 | .19 | 0 |
| Backward Speed Skate | 60' | 4.08 | ± 0.28 | 4.60 | ± 0.34 | .52 | .06 |
| | 90' | 5.86 | ± 0.36 | 6.58 | ± 0.51 | .72 | .15 |
| | 120' | 7.57 | ± 0.47 | 8.51 | ± 0.65 | .94 | .18 |
| Agility Skate | | 9.31 | ± 0.33 | 10.42 | ± 0.56 | 1.11 | .23 |
| Modified Marcotte's Puck Control Skate | | 15.09 | ± 0.76 | 17.24 | ± 0.77 | 2.15 | .01 |
| Hansen's Modified Puck Control Skate | | 19.33 | ± 1.42 | 22.28 | ± 1.26 | 2.95 | .16* |
| Macnab-Gill Backward Agility Skate | | 9.13 | ± 0.46 | 11.19 | ± 1.38 | 2.06 | .92 |

Note: In all cases, the mean scores of the Mite $A_1$ team were higher and the variances of the Mite $A_1$ team, as depicted by S.D., were smaller except where denoted by *.

[a] Means represented in seconds

the Mite $A_1$ team produced faster mean times than the Mite $B_1$ team by .52, .72, and .94 seconds, respectively. The differences in the variances at the three distances were .06, .15, and .18 S.D., respectively. At all three distance marks, the Mite $A_1$ team had smaller variances.

In the four remaining hockey skill tests, the Mite $A_1$ team produced superior mean scores. On the Agility Skate, the Mite $A_1$ team mean score was 1.11 seconds faster than the Mite $B_1$ team mean score and with a variance difference of .23 S.D. less. For the Modified Marcotte and Hansen's Modified Puck Control tests, the Mite $A_1$ means scores were superior by 2.15 seconds and 2.95 seconds, respectively. The variance difference for the two puck control tests were .01 and .16 S.D., respectively. In the Hansen test, the Mite $B_1$ team displayed lower standard deviations. In the Macnab-Gill Backward Agility skate, the differences in the mean score and the variance for the two teams were 2.06 seconds and .92 S.D., respectively. In this case, the Mite $A_1$ team proved to have the faster mean time and smaller variance.

Pre-season vs. post-season comparisons. It has already been noted that the Mite $A_1$ team's mean scores were superior to those of the Mite $B_1$ team for all the hockey variables at both pre-season and post-season (Table II).

Table V presents the differences of the means and standard deviations within each team from pre- to post-season for all the hockey tests. Table V also presents the differences in the rate or change from pre- to post-season. In general, both teams improved their mean times and decreased their respective variances on all of the hockey tests. It was also observed that the rates of change in means and standard

TABLE V DIFFERENCES OF THE MEANS AND STANDARD DEVIATIONS OF THE HOCKEY TESTS WITHIN THE MITE $A_1$ AND MITE $B_1$ TEAMS BETWEEN PRE- AND POST-SEASON, AND THE DIFFERENCES IN THE RATES OF CHANGE

| | | TEAM | PRE-SEASON MEAN | ± S.D. | POST-SEASON MEAN | ± S.D. | DIFFERENCE MEAN | ± S.D. | DIFFERENCE IN RATE OF CHANGE MEAN | ± S.D. |
|---|---|---|---|---|---|---|---|---|---|---|
| Forward Speed Skate | 60' | Mite $A_1$ | 3.06 | 0.17 | 2.91 | 0.10 | .15 | .07 | .25 | .05 |
| | | Mite $B_1$ | 3.41 | 0.23 | 3.01 | 0.11 | .40 | .12 | | |
| | 90' | Mite $A_1$ | 4.58 | 0.20 | 4.19 | 0.14 | .39 | .06 | .03 | .05 |
| | | Mite $B_1$ | 4.81 | 0.28 | 4.39 | 0.17 | .42 | .11 | | |
| | 120' | Mite $A_1$ | 5.51 | 0.16 | 5.47 | 0.18 | .04 | .02* | .44 | .21 |
| | | Mite $B_1$ | 6.14 | 0.37 | 5.66 | 0.18 | .48 | .19 | | |
| Backward Speed Skate | 60' | Mite $A_1$ | 4.37 | 0.32 | 4.08 | 0.28 | .29 | .04 | .55 | .52 |
| | | Mite $B_1$ | 5.44 | 0.90 | 4.60 | 0.34 | .84 | .56 | | |
| | 90' | Mite $A_1$ | 6.39 | 0.41 | 5.86 | 0.36 | .53 | .05 | .58 | .79 |
| | | Mite $B_1$ | 7.69 | 1.35 | 6.58 | 0.51 | 1.11 | .84 | | |
| | 120' | Mite $A_1$ | 7.88 | 0.51 | 7.57 | 0.47 | .31 | .04 | 1.02 | 1.37 |
| | | Mite $B_1$ | 9.84 | 2.06 | 8.51 | 0.65 | 1.33 | 1.41 | | |
| Agility Skate | | Mite $A_1$ | 11.75 | 0.74 | 9.31 | 0.33 | 2.44 | .41 | .17 | .21 |
| | | Mite $B_1$ | 13.03 | 1.18 | 10.42 | 0.56 | 2.61 | .62 | | |
| Modified Marcotte's Puck Control Skate | | Mite $A_1$ | 16.44 | 0.95 | 15.09 | 0.76 | 1.35 | .19 | 1.02 | 1.42 |
| | | Mite $B_1$ | 19.61 | 2.38 | 17.24 | 0.77 | 2.31 | 1.61 | | |

continued...

| | TEAM | PRE-SEASON MEAN | PRE-SEASON ± S.D. | POST-SEASON MEAN | POST-SEASON ± S.D. | DIFFERENCE MEAN | DIFFERENCE ± S.D. | DIFFERENCE IN RATE OF CHANGE MEAN | DIFFERENCE IN RATE OF CHANGE ± S.D. |
|---|---|---|---|---|---|---|---|---|---|
| Hansen's Modified Puck Control Skate | Mite $A_1$ | 21.34 | 1.44 | 19.33 | 1.42 | 2.02 | .02 | 2.50 | 1.88 |
| | Mite $B_1$ | 26.80 | 3.16 | 22.28 | 1.26 | 4.52 | 1.90 | | |
| Macnab-Gill Backward Agility Skate | Mite $A_1$ | 11.12 | 0.53 | 9.13 | 0.46 | 1.99 | .07 | 1.70 | 1.12 |
| | Mite $B_1$ | 14.88 | 2.57 | 11.19 | 1.38 | 3.69 | 1.19 | | |

*Represents an increase of variance

[a]Means represented in seconds

Note: In all cases, except that denoted by *, the differences in means and standard deviations represents an improvement in means and an attainment of smaller standard deviations. The differences in the rate of change of the means and standard deviations were due to Mite $B_1$ team decreasing their respective mean scores and standard deviations more so than that of the Mite $A_1$ team.

deviations for the Mite $B_1$ team were greater than the rates of change for the Mite $A_1$ team on all hockey tests. The Mite $B_1$ team improved their mean scores and decreased their variances more so than the Mite $A_1$ team during the course of the season.

On the Forward Speed Skating test, the Mite $A_1$ team's mean scores improved and standard deviations decreased by .15 secs and .07 S.D.; .39 secs and .06 S.D., in the 60 and 90 foot marks, respectively. At the 120 foot distance, the mean score improved by .04 secs, but the variance increased by .02 S.D. The Mite $B_1$ team's mean scores improved and standard deviations decreased by .40 secs and .12 S.D.; .42 secs and .11 S.D.; and .48 secs and .19 S.D. at the 60, 90 and 120 foot distances, respectively. The Mite $B_1$ team mean scores demonstrated greater improvement than those of the Mite $A_1$ team at all three distances. Their improvements were better by .25, .03 and .44 seconds at the 60, 90 and 120 foot distances, respectively. Decreases in the variance were also greater for the Mite $B_1$ team mean scores by .05 S.D. at both the 60 and 90 foot marks. At the 120 foot mark, the Mite $B_1$ team variance decreased by .19 S.D but the Mite $A_1$ team displayed an increase of .02 S.D., resulting in a difference of .21 S.D. between the two teams.

The Backward Speed Skating changes in mean scores displayed a similar trend as in the forward speed skating test, although the improvements were greater, particularly for the case of the Mite $B_1$ team. The Mite $A_1$ and Mite $B_1$ team mean scores improved at the 60, 90 and 120 foot marks by .29, .53 and .31 seconds, and .84, 1.11 and 1.33 seconds, respectively. The Mite $B_1$ mean score improvements were superior to those of the Mite $A_1$ team mean scores by .55, .58 and 1.02 seconds at the 60, 90 and 120 foot distances, respectively. The variance changes

as depicted by the differences between standard deviations of the mean scores, were similar for both teams, but decreased more for the Mite $B_1$ team. The Mite $A_1$ team decreased the variance at the 60 foot distance by .04 S.D. whereas the Mite $B_1$ team decreased their respective variance by .56 S.D. - a difference in decrease of .52 S.D. At the 90 and 120 foot distances, the variances decreased by .05 and .04 S.D., respectively, for the mean scores of the Mite $A_1$ team. The variances for the Mite $B_1$ team mean scores decreased by .84 and 1.41 S.D. at the same respective distances. The Mite $B_1$ team variances decreased more than those of the Mite $A_1$ team by .79 and 1.37 S.D. at the 90 and 120 foot distances, respectively.

For the Agility Skate test, the Mite $A_1$ team and Mite $B_1$ team displayed respective improvements in mean scores by 2.44 and 2.61 seconds, with the Mite $B_1$ team displaying a greater improvement of .17 seconds. The variances of the mean scores for the Mite $A_1$ and Mite $B_1$ team decreased by .41 S.D. and .62 S.D., respectively - a difference of .21 S.D.

In the two puck control tests, Hansen Modified and the Modified Marcotte, both teams displayed improvements. The Mite $A_1$ team improved by 1.35 seconds in the Modified Marcotte's puck control skate, while the Mite $B_1$ team improved their mean scores by 2.37 secs. This demonstrated a greater improvement on the part of the Mite $B_1$ team of 1.02 seconds. The variance of the mean scores decreased for the Mite $A_1$ and Mite $B_1$ teams by .19 and 1.61 S.D., respectively - a difference in decrease of 1.42 S.D. The Hansen test mean scores changed similarly. The Mite $A_1$ team improved their mean score by 2.02 secs and decreased the variance by only .02 S.D. On the other hand, the Mite $B_1$ team improved their

mean score by 4.52 secs and decreased the variance by 1.90 S.D., which displays a greater improvement in mean score of 2.50 secs and a greater decrease in variance of 1.88 S.D. In the Hansen test, the Mite $B_1$ team actually achieved the lower variance.

In the final hockey test, the Macnab-Gill Backward Agility skate, the Mite $A_1$ and Mite $B_1$ teams improved their mean scores by 1.99 and 3.69 seconds, respectively. The Mite $B_1$ team has the greater improvement in mean score by 1.70 seconds. The variance of the mean scores decreased for the Mite $A_1$ and Mite $B_1$ teams by .07 S.D. and 1.19 S.D., respectively displaying a greater decrease of 1.12 S.D. for the Mite $B_1$ team.

<u>Comparison of the teams based on grip strength</u>

Grip strength results for each individual are presented in Appendix F.

The means and standard deviations of left and right grip strength are presented in Table VI for both teams. Table VI also shows the results of the comparisons between means.

The Mite $A_1$ team and Mite $B_1$ team acquired mean scores of 20.07 $\pm$ 2.95 kg and 19.36 $\pm$ 3.03 kg, respectively, on the left grip strength variable. For the right grip strength, the Mite $A_1$ team acquired a mean score of 21.07 $\pm$ 2.34 kg, while the Mite $B_1$ team acquired a mean score of 19.93 $\pm$ 2.90 kg. Though the Mite $A_1$ team had the higher means on both left and right grip strength, the differences between the mean scores were found not to be significant ($p$ .05).

<u>Comparison of the teams based on the CAHPER fitness performance test</u>

Raw scores of the various test items for each individual are presented in Appendix G.

TABLE VI COMPARISONS OF THE MITE $A_1$ AND MITE $B_1$ TEAM MEANS BASED ON GRIP STRENGTH

| TEST ITEM | TEAM | N | MEAN | STANDARD DEVIATION | STANDARD ERROR | T VALUE | 2-TAIL PROBABILITY |
|---|---|---|---|---|---|---|---|
| Left Grip Strength (kg) | Mite $A_1$ | 14 | 20.07 | 2.95 | 0.79 | -0.63 | 0.533 |
| | Mite $B_1$ | 14 | 19.36 | 3.03 | 0.81 | | |
| Right Grip Strength (kg) | Mite $A_1$ | 14 | 21.07 | 2.34 | 0.62 | -1.15 | 0.261 |
| | Mite $B_1$ | 14 | 19.93 | 2.90 | 0.77 | | |

Table VII presents the means and standard deviations and results of the comparisons between means on all test items.

The Mite $A_1$ team achieved a mean score of 66.71 $\pm$ 3.93 ins on the standing broad jump test while the Mite $B_1$ team mean score was 65.18 $\pm$ 2.66 ins. Though the Mite $A_1$ team had the longer jump, the difference from the Mite $B_1$ team was not significant ($p > .05$).

In the shuttle run, the differences between mean scores was also found not to be significant ($p > .05$) although the Mite $A_1$ team exemplified a faster time of 11.66 $\pm$ .53 secs as compared to the Mite $B_1$ team's mean time of 11.91 $\pm$ .39 secs.

The one minute speed sit-ups test depicts a difference of 6.29 sit-ups between the two teams. This difference was found to be significant ($p < .05$). The Mite $A_1$ team performed 48.29 $\pm$ 6.03 sit-ups on the average. The Mite $B_1$ team performed 42.00 $\pm$ 7.92 sit-ups on the average.

In the flexed arm hang test, the Mite $A_1$ team acquired a mean score of 64.79 $\pm$ 19.62 secs. The Mite $B_1$ team was able to maintain a flexed arm hang for 49.64 $\pm$ 18.38 secs on the average. This produced a difference in mean scores of 15.15 secs, which was found to be significant ($p < .05$). Large variances, as depicted by the standard deviations, were observed for both teams.

For the 50 yard dash and 300 yard run, the Mite $A_1$ team achieved mean scores of 7.79 $\pm$ 0.21 secs and 62.33 $\pm$ 3.07 secs, respectively. The Mite $B_1$ team achieved mean scores of 8.13 $\pm$ 0.38 secs and 66.03 $\pm$ 2.42 secs, respectively. In both cases, the Mite $A_1$ team produced faster mean times. The differences in mean scores between the teams for the 50 yard dash and 300 yard run were .34 secs and 3.70 secs,

TABLE VII COMPARISONS OF THE MITE $A_1$ AND MITE $B_1$ TEAM MEANS BASED ON THE C.A.H.P.E.R. FITNESS PERFORMANCE TEST

| TEST ITEM | TEAM | N | MEAN | STANDARD DEVIATION | STANDARD ERROR | T VALUE | 2-TAIL PROBABILITY |
|---|---|---|---|---|---|---|---|
| One minute speed sit-ups(no.) | Mite $A_1$ | 14 | 48.29 | 6.03 | 1.61 | -2.36 | 0.026 |
| | Mite $B_1$ | 14 | 42.00 | 7.92 | 2.12 | | |
| Standing broad jump (ins.) | Mite $A_1$ | 14 | 66.71 | 3.93 | 1.05 | -1.21 | 0.236 |
| | Mite $B_1$ | 14 | 65.18 | 2.66 | 0.71 | | |
| Shuttle run (secs) | Mite $A_1$ | 14 | 11.66 | 0.53 | 0.14 | 1.43 | 0.165 |
| | Mite $B_1$ | 14 | 11.91 | 0.39 | 0.10 | | |
| Flexed Arm Hang (secs) | Mite $A_1$ | 14 | 64.79 | 19.62 | 5.24 | -2.11 | 0.045 |
| | Mite $B_1$ | 14 | 49.64 | 18.38 | 4.91 | | |
| 50 Yd. Dash (secs) | Mite $A_1$ | 14 | 7.79 | 0.21 | 0.06 | 2.93 | 0.007 |
| | Mite $B_1$ | 14 | 8.13 | 0.38 | 0.10 | | |
| 300 Yd. Run (secs) | Mite $A_1$ | 14 | 62.33 | 3.07 | 0.82 | 3.54 | 0.002 |
| | Mite $A_1$ | 14 | 66.03 | 2.42 | 0.65 | | |

respectively. For both tests, the difference between team means were found to be significant ($p < .01$).

Comparison of the teams based on $PWC_{170}$

Values for the individual $PWC_{170}$ results are presented in Appendix H.

Table VIII presents the mean $PWC_{170}$ scores for the two teams. Means are expressed as kpm/min and kpm/kg body weight/min. Results of the comparisons of the means are also presented in Table VIII.

The Mite $A_1$ team obtained a mean score of $525.82 \pm 47.45$ kpm/min while the Mite $B_1$ team obtained a mean score of $448.67 \pm 74.29$ kpm/min. A difference of 77.15 kpm/min resulted. This was found to be significant at the .01 level.

With the influence of body weight removed, by expressing $PWC_{170}$ in terms of kpm/kg body weight/min, the Mite $A_1$ team still produced a higher mean score of $15.72 \pm 2.14$ kpm/kg/min as compared to the Mite $B_1$ mean score of $13.39 \pm 2.11$ kpm/kg/min. The difference between means was found to be significant at the .01 level.

Relationships of all variables to one another

Intercorrelations of all the test variables are presented in Appendix I. From this, subsequent tables comparing non-specific hockey variables to the hockey test items and hockey variables to one another were derived.

Relationships of hockey test items to one another

In order to observe the degree of specificity of individual differences among the hockey test items, intercorrelations of the hockey test items were calculated. Table IX presents the intercorrelations.

TABLE VIII COMPARISONS OF THE MITE $A_1$ AND MITE $B_1$ TEAM MEANS BASED ON PHYSICAL WORK CAPACITY ($PWC_{170}$)

| VARIABLE | TEAM | N | MEAN | STANDARD DEVIATION | STANDARD ERROR | T VALUE | 2-TAIL PROBABILITY |
|---|---|---|---|---|---|---|---|
| PWC 170 (kpm/min) | Mite $A_1$ | 14 | 525.82 | 47.45 | 12.68 | -3.27 | 0.003 |
| | Mite $B_1$ | 14 | 448.67 | 74.29 | 19.85 | | |
| PWC 170 (kpm/kg/ min) | Mite $A_1$ | 14 | 15.72 | 2.14 | 0.56 | -2.91 | 0.007 |
| | Mite $B_1$ | 14 | 13.39 | 2.11 | 0.57 | | |

From observation of the table, only one correlation coefficient was found not to be significant ($p > .05$). This was between the 60 ft interval of the forward speed skate and Hansen's modified puck control skate. Most other correlation coefficients were significantly different from zero at the .01 level. The table shows that the forward speed skating distances are correlated to one another highly. At the same time, the backward speed skating distances are also correlated with one another highly. In regards to the two puck control skates and agility skates, they too correlated well with one another, although the Hansen vs the backward agility skate produces a somewhat lower correlation (.66) as compared to the other intercorrelations.

Although most of the intercorrelations are significant, with some being very high, there seems to be a slight trend of specificity of individual differences. The forward speed skate does not correlate as highly to the two agility skates and two puck control skates as does the backward speed skate. Nor does forward speed skate correlate highly to the backward speed skate. The backward speed skate does not correlate to the two puck control skates and forward agility skate as highly as do the two puck control skates and forward agility skate correlate with one another. It does however, correlate highly with the backward agility skate.

Relationships of age, height and weight to hockey test items

In Table X, the correlation coefficients obtained when age, height and weight were compared to the hockey test items are presented.

When age, height and weight were compared to the forward speed skate distances, higher correlation coefficients were obtained than when age, height and weight were compared to any other hockey test. Height

TABLE IX INTERCORRELATION COEFFICIENTS OF THE HOCKEY TEST ITEMS

| | | 1a | 1b | 1c | 2a | 2b | 2c | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. Forward Speed Skate | a. 60' | - | .88 | .78 | .52 | .48 | .51 | .43 | .52 | .36 | .53 |
| | b. 90' | | - | .85 | .64 | .62 | .65 | .58 | .67 | .49 | .67 |
| | c. 120' | | | - | .63 | .61 | .67 | .59 | .61 | .40 | .68 |
| 2. Backward Speed Skate | a. 60' | | | | - | .96 | .96 | .63 | .67 | .52 | .60 |
| | b. 90' | | | | | - | .96 | .64 | .66 | .52 | .79 |
| | c. 120' | | | | | | - | .71 | .68 | .51 | .84 |
| 3. Agility Skate | | | | | | | | - | .88 | .72 | .77 |
| 4. Modified Marcotte's Puck Control Skate | | | | | | | | | - | .81 | .79 |
| 5. Hansen's Modified Puck Control Skate | | | | | | | | | | - | .66 |
| 6. MacNab-Gill Backward Agility Skate | | | | | | | | | | | - |

Critical r's .05 = .37

.01 = .48

Note: Hockey test results were recorded in seconds.

TABLE X CORRELATION COEFFICIENTS OBTAINED WHEN THE RESULTS OF AGE, HEIGHT AND WEIGHT WERE COMPARED TO THE RESULTS OF THE INDIVIDUAL HOCKEY TESTS

| | | AGE (yrs) | HEIGHT (cm) | WEIGHT (kg) |
|---|---|---|---|---|
| Forward Speed Skate | 60' | -.36 | -.55 | -.51 |
| | 90' | -.40 | -.61 | -.49 |
| | 120' | -.40 | -.51 | -.49 |
| Backward Speed Skate | 60' | -.13 | -.25 | -.13 |
| | 90' | -.20 | -.28 | -.15 |
| | 120' | -.16 | -.32 | -.19 |
| Agility Skate | | -.10 | -.26 | -.20 |
| Modified Marcotte's Puck Control Skate | | -.19 | -.26 | -.18 |
| Hansen's Modified Puck Control Skate | | -.21 | -.11 | -.06 |
| Macnab-Gill Backward Agility Skate | | -.25 | -.36 | -.19 |

Critical r's .05 = .37

.01 = .48

Note: Hockey test results were recorded in seconds

versus the forward speed skate produced the highest correlations at all three distance intervals. At the 60, 90 and 120 ft intervals, the r values were -.55, -.61 and -.51, respectively ($p < .01$). Weight vs the forward speed skate produced the second highest r values. At 60, 90 and 120 intervals, the r values were -.51, -.49 and -.49, respectively (all significant, p .01). Age vs the forward speed skate produced the third highest correlation coefficients. At the 60, 90 and 120 ft intervals, the r values were -.36, -.40 and -.40, respectively ( the latter two significant, $p < .05$).

The age, height and weight correlation coefficients obtained when they were compared individually to all the remaining tests were low and not significant ($p > .05$).

It appears that body size is more related to forward speed skating ability than to other forms of hockey tests.

Relationships of the CAHPER fitness performance test items to the hockey test items

It is evident, from observing Table XI, that not a high degree of relationship exists between fitness performance items and the hockey test items.

When the 50 yard dash was correlated with the fitness performance items, the correlation coefficients were low. The 50 yard dash vs the agility skate reached a significant r value of .39 ($p < .05$).

When the flexed arm hang was correlated with the fitness performance items, the correlation coefficients with the forward speed skate were almost non-existant. The correlation coefficients were higher with the other hockey tests. Of the remaining hockey tests, four correlation coefficients were found to be significant - with backward

TABLE XI CORRELATION COEFFICIENTS OBTAINED WHEN THE RESULTS OF THE INDIVIDUAL C.A.H.P.E.R. FITNESS PERFORMANCE TEST ITEMS WERE COMPARED TO THE RESULTS OF THE INDIVIDUAL HOCKEY TESTS

| | | 50 YD DASH (sec) | FLEXED ARM HANG (sec) | SHUTTLE RUN (sec) | SPEED SIT-UPS (no) | STANDING BROAD JUMP (ins) | 300 YARD RUN (sec) |
|---|---|---|---|---|---|---|---|
| Forward Speed Skate | 60' | .22 | -.19 | .00 | -.37 | -.19 | .19 |
| | 90' | .27 | -.17 | -.01 | -.36 | -.26 | .22 |
| | 120' | .21 | -.01 | .07 | -.46 | -.26 | .16 |
| Backward Speed Skate | 60' | .25 | -.47 | .21 | -.38 | -.33 | .23 |
| | 90' | .27 | -.46 | .27 | -.44 | -.33 | .31 |
| | 120' | .25 | -.34 | .27 | -.37 | -.34 | .24 |
| Agility Skate | | .39 | -.28 | .18 | -.30 | -.20 | .44 |
| Modified Marcotte's Puck Control Skate | | .34 | -.38 | .19 | -.27 | -.28 | .53 |
| Hansen's Modified Puck Control Skate | | .24 | -.46 | .18 | -.27 | -.09 | .42 |
| Macnab-Gill Backward Agility Skate | | .18 | -.30 | .13 | -.36 | -.29 | .39 |

Critical r's .05 = .37

.01 = .48

Note: Hockey test results were recorded in seconds

60 ft distance an r of -.47 resulted ($p < .05$); with backward 90 ft distance an r of -.46 resulted ($p < .05$); with modified Marcotte's puck control an r of -.38 resulted ($p < .05$); and with Hansen's modified puck control an r of -.46 resulted ($p < .05$). In general, the flexed arm hang shows a higher degree of relationship with hockey tests that involve more skill.

Correlation coefficients obtained when the shuttle run was compared to the hockey tests were all low and none were found to be significant ($p > .05$).

Speed sit-ups correlated higher with the forward and backward speed skates and the backward agility skate than to the two puck control tests and forward agility skate. The r values were all similar for the three distances of the forward and backward speed skate and backward agility skate. Correlation coefficients were significant at the .05 level on the 60 and 120 forward speed skate. The highest r value was at the 120 ft interval (r of -.46). The correlation coefficient with all three distances of the backward speed skate were significantly different from zero at the .05 level. The highest r value was at the 90 ft interval (r of -.44). The backward agility skate correlated with the speed sit-ups with an r value of -.36 ($p > .05$).

The relationship of the standing broad jump to the hockey test items are all low and non-significant ($p > .05$). The highest correlations were obtained with the backward speed skate at all three distance intervals.

The 300 yard run correlated with the forward and backward speed skates non-significantly ($p > .05$). The r values obtained when the 300 yard run were compared to the two puck control skates, forward agility

skate and backward agility skate were all found to be significant. The Modified Marcotte's puck control skate's r value reached the .01 level. It appears that the correlation coefficients are higher when the 300 yard run is compared to tests that take a longer time to complete.

Relationships of grip strength to hockey test items

In Table XII, correlation coefficients obtained from comparing each hockey test variable to right and left grip strengths are presented.

When comparisons of left grip strength to the hockey test items were made, all correlation coefficients, except for the forward speed skate, were low and not significant ($p > .05$). The forward speed skate at the 60, 90 and 120 ft intervals produced r values of -.53, -.42 and -.43, respectively. At the 60 ft interval, the correlation was significant at the .05 level. The 60 and 90 ft r values were significant at the .01 level.

When comparing right grip strengths to the individual hockey tests, higher correlations were obtained as compared to left grip strength coefficients. The values for r at the 60, 90 and 120 ft interval distances of the forward speed skate were -.52, -.52, and -.54, respectively (all significant, $p < .01$). Lower but significant correlations (p .05) of -.38, -.38 and -.41 were obtained when right grip strength was compared to the 120 ft interval of the backward speed skate, agility skate and Macnab-Gill backward agility skate, respectively.

Relationships of physical work capacity to hockey test items

Correlation coefficients, when comparing physical work capacity ($PWC_{170}$) expressed in terms of kpm/min and kpm/kg body weight/min to all the hockey test items, are presented in Table XIII.

Higher r values were obtained with $PWC_{170}$ (kpm/min) comparisons

TABLE XII CORRELATION COEFFICIENTS OBTAINED WHEN THE RESULTS OF THE RIGHT AND LEFT GRIP STRENGTHS WERE COMPARED TO THE RESULTS OF THE INDIVIDUAL HOCKEY TESTS

| | | RIGHT GRIP STRENGTH (kg) | LEFT GRIP STRENGTH (kg) |
|---|---|---|---|
| Forward Speed Skate | 60' | -.52 | -.53 |
| | 90' | -.52 | -.42 |
| | 120' | -.54 | -.43 |
| Backward Speed Skate | 60' | -.32 | -.11 |
| | 90' | -.32 | -.18 |
| | 120' | -.38 | -.14 |
| Agility Skate | | -.38 | -.21 |
| Modified Marcotte's Puck Control Skate | | -.28 | -.18 |
| Hansen's Modified Puck Control Skate | | -.12 | -.16 |
| Macnab-Gill Backward Agility Skate | | -.41 | -.19 |

Critical r's .05 = .37

.01 = .48

Note: Hockey test results were recorded in seconds

TABLE XIII CORRELATION COEFFICIENTS OBTAINED WHEN THE RESULTS OF THE PHYSICAL WORK CAPACITY TEST WAS COMPARED TO THE RESULTS OF THE INDIVIDUAL HOCKEY TESTS

| | | PWC 170 (kpm/min) | PWC 170 (kpm/kg/min) |
|---|---|---|---|
| Forward Speed Skate | 60' | -.34 | .05 |
| | 90' | -.46 | -.07 |
| | 120' | -.33 | .04 |
| Backward Speed Skate | 60' | -.43 | -.34 |
| | 90' | -.44 | -.33 |
| | 120' | -.46 | -.32 |
| Agility Skate | | -.28 | -.15 |
| Modified Marcotte's Puck Control Skate | | -.42 | -.28 |
| Hansen's Modified Puck Control Skate | | -.36 | -.31 |
| Macnab-Gill Backward Agility Skate | | -.39 | -.26 |

Critical r's .05 = .37

.01 = .48

Note: Hockey test results were recorded in seconds

than with $PWC_{170}$ (kpm/kg/min) comparisons. Comparisons between $PWC_{170}$ (kpm/min) and all the hockey variables produced correlation coefficients ranging from -.28 to -.46. Of these, the 90 ft forward skate, 60 ft backward skate, 90 ft backward skate, 120 ft backward skate, Modified Marcotte's puck control skate, and Macnab-Gill backward agility skate were found to be significant ($p < .05$).

The correlation coefficients of the $PWC_{170}$ (kpm/kg/min) to the hockey test items were found to be all non-significant ($p > .05$). An interesting point however, is with the affect of body weight removed ($PWC_{170}$ kpm/kg/min), the correlations most affected are the forward speed skate distances. When $PWC_{170}$ is expressed in terms of kpm/kg body weight/min, almost no correlation exists with the 60, 90 and 120 ft intervals of the forward speed skate, whereas $PWC_{170}$ (kpm/min) relationship with the same variables could explain 11% to 21% of the variance. The backward speed skate, at all time interval distances, appears to be least affected by removing the effects of body weight.

Relationships of "in vivo" hockey performance to the hockey test items

Correlation coefficients were obtained between the coaches' subjective ranking of the 28 hockey players "in vivo" hockey performance and the individual hockey test items. All r values were found to be significant ($p < .05$) (Table XIV).

From observing Table XIV, lower correlations were obtained for relationships existing between the three interval distances of the forward speed skate and "in vivo" hockey performance. Somewhat higher correlations were obtained when comparisons between the three interval distances of the backward speed skate were made. Even higher correlations were obtained for those tests involving a higher degree of

TABLE XIV CORRELATION COEFFICIENTS OBTAINED WHEN "IN VIVO" HOCKEY PERFORMANCE WAS COMPARED TO THE RESULTS OF THE INDIVIDUAL HOCKEY TESTS

| | | "IN VIVO" HOCKEY PERFORMANCE |
|---|---|---|
| Forward Speed Skate | 60' | .49 |
| | 90' | .59 |
| | 120' | .59 |
| Backward Speed Skate | 60' | .66 |
| | 90' | .66 |
| | 120' | .69 |
| Agility Skate | | .87 |
| Modified Marcotte's Puck Control Skate | | .90 |
| Hansen's Modified Puck Control Skate | | .73 |
| Macnab-Gill Backward Agility Skate | | .85 |

Critical r's .05 = .37

.01 = .48

Note: Hockey test results were recorded in seconds

complexity. The Hansen's test produced the lowest r of .73 as compared with the other three skill tests. The Macnab-Gill backward agility skate, agility skate, and modified Marcotte's puck control skate, produced correlations of .85, .87 and .90, respectively, when compared to "in vivo" hockey performance. In other words, performance of any one of the latter three tests can explain a minimum of 72% of the variance of the coaches' subjective measure of hockey performance.

<u>Determining the best predictors of "in vivo" hockey performance from results of all the test variables</u>

In Table XV is the summary of the multiple regression analysis used to determine the best predictors of "in vivo" hockey performance. From observation of the table, the modified Marcotte's puck control test produced a correlation with hockey performance of .90 when influences of other variables were partialled out. This test alone could explain 80% of the variance of hockey performance. Only the Macnab-Gill backward agility skate, when combined with the Marcotte test, could change the $R^2$ more than 4%. It's addition improved the $R^2$ by 6%. Remember that the termination of the stepwise regression was when the addition of a variable to the regression equation could not improve the $R^2$ by more than 4% (i.e., what one variable on its own would correlate to hockey performance - 1/25 or 4%). As a result, the stepwise multiple regression was stopped after the addition of the Macnab-Gill test. These two tests produced a multiple R of .93, which could explain 86% of the variance of the hockey performance ranking.

Thus, the best equation developed to predict "in vivo" hockey performance was $y = -67.15 + 3.71 (X_1) + 2.14 (X_2)$, whereas $X_1$ represents a score on the modified Marcotte test and $X_2$ represents a score on the Macnab-Gill backward agility skate.

TABLE XV SUMMARY OF THE MULTIPLE REGRESSION ANALYSIS USED TO DETERMINE THE BEST PREDICTORS OF "IN VIVO" HOCKEY PERFORMANCE

| VARIABLE | b | STANDARD ERROR OF b | MULTIPLE R | $R^2$ | $R^2$ CHANGE |
|---|---|---|---|---|---|
| Modified Marcotte's Puck Control Skate | 3.71 | 0.77 | .90 | .80 | .80 |
| Macnab-Gill Backward Agility Skate | 2.14 | 0.70 | .93 | .86 | .06 |
| . . . | . . . | . . . | . . . | . . . | . . . |

Constant = -67.15

ANALYSIS OF VARIANCE

| SOURCE | DF | MSQ | F |
|---|---|---|---|
| Regression | 2 | 781.67 | 74.12* |
| Residual | 25 | 10.55 | |

*P < .001

[a] Variables are listed in order in which they entered the stepwise multiple regression analysis

[b] Regression analysis was terminated

# DISCUSSION

One of the primary goals of providing participation in sporting activities is that ultimately individuals who demonstrate superior performance in any given sport are produced. In order to do this, a "pyramid system" is employed. The base of the pyramid is wide, allowing for varying degrees of individual abilities. As one moves up the pyramid, individuals who demonstrate superior performance are evident. The peak of the pyramid represents individuals who supposedly possess the ultimate in sporting performance.

The sport of ice hockey is based on this system. At the base of the pyramid many hockey teams are evident, which allows for participation of a large number of individuals ranging in levels of ability. As one moves up the pyramid there are fewer and fewer hockey teams, and thus hockey players are observed. Ultimately, a team or teams, are produced which are made up of players who are similar in hockey abilities and who all demonstrate superior hockey performance as compared to the remaining hockey population.

"Sub-pyramids" are also formed within each level of the overall pyramid. In hockey, these "sub-pyramids" are based on age. This means that within each age group, teams of varying levels of hockey proficiency are formed and subsequent leagues based on the level of performance are provided. This allows for competition between teams of similar hockey playing abilities within each age group. Generally, the players who exhibit superior hockey playing abilities at a given age move to the

upper levels of the "sub-pyramid" in the following age group if they wish to continue participation in the sport of ice hockey. This system also provides for those individuals who did not exhibit high levels of hockey abilities at one age group, to move up to a "sub-pyramid" level of the subsequent age where greater levels of hockey abilities are required. This is providing, of course, that the particular individuals had improved their hockey abilities in the previous year.

How a hockey player attains a higher level on the pyramid is dependent not only on his hockey proficiency but on how the particular coach perceives his hockey playing ability. In the present investigation, two teams of ice hockey were observed. The Mite $A_1$ team represented individuals who had demonstrated superior hockey abilities in team try-outs as perceived by the respective coaches. The Mite $B_1$ team consisted of individuals who had demonstrated inferior hockey abilities as compared to the Mite $A_1$ team. The team selections were not influenced in any way by this investigator.

In order to determine if the Mite $A_1$ team members did indeed possess superior hockey playing abilities, a number of hockey tests were given to players of both teams. The results in Table III shows the Mite $A_1$ team acquiring obvious superior mean scores on all of the hockey tests. If the assumption is made that these hockey teams measure an individual's hockey playing abilities (Table XIV), then it stands that the coaches' perception of superior hockey playing ability was accurate.

Another purpose of this investigation was to observe if the differences between the hockey teams persisted at the conclusion of the hockey season. It was found that the Mite $A_1$ team remained superior in terms of hockey test execution at post-season (Table IV). When the

results for both teams were compared to hockey test results of 10 to 11 year olds in the Hansen et al. (1970) study, both the Mite $A_1$ and Mite $B_1$ teams proved to be superior.

In regards to the differences between the two teams at post-season compared to the differences at pre-season, the Mite $B_1$ team had improved in all hockey tests more so than the improvement of the Mite $A_1$ team. This is evident by the greater rate of change on the part of the Mite $B_1$ team in Table V. This occurred despite the fact that the Mite $A_1$ team had improved substantially over the course of the season.

As to the reason why the Mite $B_1$ team improved more so than the Mite $A_1$ team is difficult to ascertain, since a number of causes may have been operating.

The most obvious explanation is that the Mite B league provided games which were more conducive to hockey ability improvements. This seems highly improbable in light of the fact that when this investigator observed hockey games of the two teams, the Mite A league, by far, provided games that were more competitive, requiring complex hockey skill executions.

Another explanation offered is that the individuals of the Mite $A_1$ team had been introduced to the hockey tests in previous years and on a number of occasions, whereas the Mite $B_1$ team had not. As a result, the greater improvement on the part of the Mite $B_1$ team may have been due to a learning effect. Granted that the learning effect may have been a contributing factor, one might speculate that if the Mite $B_1$ team was introduced to the hockey tests at subsequent times, the difference between the two teams may decrease or diminish all together. This speculation does not receive credibility in view of Macnab's (1978) finding that in

the subsequent two years, the differences between the two teams at post-season persisted. This was the case for all test items except in the forward and backward speed skating tests, whereby Mite $B_1$ improved their mean scores more so than the improvement of the Mite $A_1$ team. This occured only in the immediately following year at which time the differences remained constant. The greater improvement in the forward and backward agility skate in the year following the present investigation may have been attributed to an additional learning effect.

There is another possible explanation to the Mite $B_1$ team's greater rate of improvement. It was observed that the variances of the Mite $B_1$ team's mean scores on all of the hockey tests, as depicted by the standard deviations of the means, were larger than the Mite $A_1$ team at pre-season (Table III). At post-season, the variances of the mean scores for the Mite $B_1$ team had decreased considerably to the point that the variance decreases were greater in the Mite $B_1$ team than the Mite $A_1$ team (Table V). This occured in all the hockey tests. It is plausible that scores of certain individuals on the Mite $B_1$ team were consistently inferior on all hockey tests to the rest of the team as a whole. In turn, the overall Mite $B_1$ team's mean scores would be negatively influenced because of a select few. By post-season, the scores of the select few may have caught up to the rest of the group on a whole. As a result, the greater improvement by the Mite $B_1$ team on all test items may have been due, at least in part, to a narrowing of the range of individual scores.

In regards to the greater rates of improvement by the Mite $B_1$ team during the course of the season, a last possible explanation is offered. It is possible that the Mite $A_1$ team was experiencing a ceiling effect in

terms of motor development. The Mite $A_1$ team players may have been performing the hockey skill tests at a higher relative degree of their motor development as compared to the Mite $B_1$ players. In this regard, the Mite $A_1$ team had less potential for improvement. On the other hand, the Mite $B_1$ team had more potential for improvement. It is possible that the only barrier impeding improvement in the execution of the hockey tests on the part of the Mite $A_1$ team was their own motor development in terms of the neuromuscular maturation rate. Thus subsequent improvements follow the rate of motor-maturation. This phenomenon is purported to occur in non-hockey motor performance tests in children (Malina, 1973).

Presented thus far are the differences that exist between the two teams on the hockey test items. It was found that the Mite $A_1$ team demonstrated superiority in hockey test executions, yet when both teams are compared to results obtained by other age matched hockey players who performed the same tests, both teams of the present investigation are superior. As to the greater rate of improvement on the part of the Mite $B_1$ team, a number of possible explanations were given. The most probable cause is a learning effect experienced by the Mite $B_1$ team with a contributing influence from the Mite $B_1$ team narrowing their respective range of individual scores and the Mite $A_1$ team's ceiling effect in terms of motor development. Despite the fact that the Mite $B_1$ team improved more so than the Mite $A_1$ team, the latter team still demonstrated superior hockey abilities which continued in subsequent years (Macnab, 1978). It is evident that the Mite $A_1$ team was made up of individuals who were better hockey players as compared to the Mite $B_1$ players. As to why the Mite $A_1$ team was superior in terms of hockey playing ability is the theme of the subsequent discussion.

In order to do this, it had to be ascertained whether or not the difference between the two teams was specific to the hockey test performed. This would allow the investigator to determine which test or tests differentiated the two teams in terms of hockey abilities.

It was found that the three distance intervals of the forward speed skate correlated well with one another (Table IX). Also, the three distances of the backward speed skate correlated highly with one another (Table IX). It was also observed that the backward speed skating distances correlated better with one another than did the three distances of the forward speed skate. In terms of the two agility skates and two puck control skates, they correlated well with one another, however, it was found that the forward speed skate did not correlate as well with the agility and puck control tests as did the backward speed skate. Also, the backward speed skate did not correlate as well with the four remaining tests as these four tests correlated with one another. As a result, the degree of specificity of individual results was higher in the forward speed skate than the other hockey tests. It seems apparent that the forward speed skating test only measured forward speed skating ability. If one scored higher in one of the agility or puck control skates the chances that he scored high on any one of the other three skill tests was good. Similar relationships were found in Hansen's study (1970) on young hockey players.

The differences between the two teams were not as high in the forward speed skating test as were the differences in the remaining hockey tests (Table IV). In the forward speed skate, the Mite $B_1$ team was 3.5%, 4.8% and 3.5% slower at the 60, 90 and 120 ft distances, respectively. On all the other tests, including the three distance intervals of the backward speed skate, the differences exhibited 12% to

22% values. The backward speed skating distances, forward agility skate, and the two puck control tests differentiated the two teams with percent values ranging from 11.9 to 15.3. The Macnab-Gill backward agility skate demonstrated that the Mite $B_1$ team was 22.6% slower than the Mite $A_1$ team. Thus the forward speed skate differentiated teams of obvious different playing abilities to a lesser degree than the other tests. The backward agility skate differentiates the two teams the most.

Factors which affect forward speed skating ability in a straight line, apparently do not affect the ability to perform tests that are more complex in nature to the same extent. In light of the fact that forward speed skating differentiated the two teams slightly, and considering that forward speed skating did not correlate as well with "in vivo" hockey performance as did the other tests (Table XIV), the specific factors affecting forward speed skating are possibly not as important for overall hockey performance. These other factors might be balance, hand-eye coordination, body coordination and agility.

Table X presented the correlations of age, height and weight to the hockey tests. It was observed that age, height and weight were related more to forward speed skating than to the other hockey tests. In particular, height and weight were more related than age. Jones (1946), Bookwalter (1950), Asmussen (1962) and Montpetit et al. (1966) all found that height correlates well with grip strength. If we assume that grip strength is a measure of overall body strength then the finding that height correlated well with forward speed skating (Table X) may be indicative of the influences of strength on forward speed skating. The fact that weight also correlated better with forward speed skating than to the other tests may indicate the influence of larger muscle mass. Supportive of this is that

Clarke et al. (1968) found that active children who were stronger, weighed more and were more mesomorphic. In the present investigation, both right and left grip strength correlated better with the forward speed skating test than to the other hockey tests with r values approximately -.50 (Table XII). In consideration of what has been discussed earlier, the finding that forward speed skating did not differentiate the teams as well as other tests, it is possible that tests requiring a greater degree of skill also require less influence from strength components than do tests that involve sheer speed and power.

Further to this, the differences between the two teams on grip strength means (Table VI) were not significant ($p > .05$). Also, the differences between the two teams on age, height and weight (Table I) were found not to be significant ($p > .05$). In light of the fact that the Mite $A_1$ team scored higher on the hockey tests and that the Mite $A_1$ team's "in vivo" performance was superior to that of the Mite $B_1$ team, it can be assumed that the Mite $A_1$ team's superior hockey abilities were due to factors other than body size and strength.

One might conjecture that the Mite $A_1$ team was more mature than the Mite $B_1$ team. Clarke and Harrison (1962) and Beunen et al. (1974) found that more mature boys were larger and scored higher on strength tests. Since the differences between the two teams were not significant in the grip strength tests and age and body size, the two teams were probably matched in terms of maturity.

Berger (1967) found that dynamic strength was more related to motor ability than static strength. As a result, it is possible that the assumption that grip strength measures overall body strength, may only be specific to overall static strength. Since hockey is a

dynamic game, we then look to other measures of strength to explain the differences in hockey abilities between the two teams.

Of those tests that presumably measure strength and power in the CAHPER fitness performance test, significant differences between teams were found on the speed sit-up test ($p < .05$) and flexed arm hang test ($p < .05$) (Table VII). They did not differ significantly on the standing broad jump test which was designed to measure explosive power. As for the significant differences on the sit-up and flexed arm tests, one might, at first hand, think that the superior hockey ability of the Mite $A_1$ team may have been due to the superior strength levels after all. But considering that the flexed arm hang test was a static strength measure as was the grip strength test primarily, then the significant differences that exist might be due to factors other than strength. It is highly probable that in both the sit-up test and flexed arm hang test, the significant difference between the two teams was due to greater motivation on the part of the Mite $A_1$ team. This seems plausible, considering that both tests can present great discomfort towards the end of each test. The Mite $B_1$ team may have then discontinued the tests due to the discomfort rather than actual muscle fatigue. On the other hand, the Mite $A_1$ team was probably accustomed to high levels of discomfort due to the highly competitive games they competed in. Another factor was that the Mite $A_1$ team may have experienced a learning effect and may have developed their own techniques to improve their performance. This is in consideration of the fact that they had been introduced to the tests more often than the Mite $B_1$ team in previous years.

The flexed arm hang test correlated poorly with the forward speed skate and better with the remaining tests (Table XI). The flexed arm hang test obtained significant correlations ($p < .05$) with the 60 and 90 foot backward speed skate, modified Marcotte's puck control skate and Hansen's modified puck control skate. A negative correlation was obtained between the flexed arm hang and height and weight (Appendix I). The significant relationship between the flexed arm hang and the aforementioned hockey tests may be a reflection of disassociation between weight and the same hockey tests as discussed earlier. As a result, the finding that the flexed arm hang correlates better with tests that require greater skill illustrates that body size and strength in ten year old boys do not play a substantial contributing role to superior hockey performance.

The speed sit-ups were significantly correlated ($p < .05$) to the forward and backward speed skates except at the 90 foot forward distance. The speed sit-ups were not significantly correlated to the agility and puck control skates. This finding illustrates further that strength is more related to speed skating than to more complex hockey tests. However, where the grip strength test did not correlate as highly to the backward speed skate as it did to the forward speed skate (Table XII), the speed sit-up test did. In regards to this latter point and in light of what has been discussed earlier (i.e., the backward speed skate correlated with grip strength better than did the agility and puck control tests), body size and strength also affects backward speed skating ability. However, the effects on backward speed skating performance are not as pronounced as the effects on forward speed skating performance. The fact that speed sit-ups measure abdominal and hip flexor muscles, explains why this particular test is related to hockey tests. It would be expected

that considering forward and backward speed skating involves the muscles of the lower half of the body, a test which partially measures those same muscles would be related to speed performance.

There was a trend for the 300 yard run of the CAHPER test to correlate higher with the agility skates and puck control skates (Table XI) than to speed skates. The 300 yard run correlated significantly at the .05 level with the backward agility skate (.39), Hansen's puck control skate (.42) and the forward agility skate (.44). The Marcotte's puck control skate correlated significantly with the 300 yard run at the .01 level (.53). This is probably due to the similarity in length of time to do the test. Those hockey tests that took longer to perform correlated better with the 300 yard run than did hockey tests which required a shorter length of time. The hockey tests did not correlate well with the 50 yard dash (Table XI) or $PWC_{170}$ (Table XIII). The results of the correlations of these tests and the correlation of the 300 yard run with the hockey tests demonstrated that some of the hockey tests involved, to an appreciable amount, the anaerobic or aerobic capabilities off the ice.

Due to the complexity of the sport of ice hockey, it is difficult to ascertain what factors were operating to produce superior hockey ability, not to mention the relative degree of importance which specific factors played. Thus far, we have inconclusively determined that body size and strength have a preferential effect on forward speed skating and not to hockey tests that require more skill, balance and agility. Hockey tests which are more complex in nature correlate better to "in vivo" hockey performance than do hockey test consisting primarily of power and speed. As a result the factors affecting performance in tests

of hockey speed and power do not differentiate hockey players on overall hockey ability. Thus, it seems evident that body size and strength in boys of similar age are not factors, of any appreciable importance, that determine a boy's ultimate hockey playing ability. Other factors seem to be operating. In light of this, Ismail et al. (1963) found that balance did not correlate well with age, height and weight in boys aged ten to twelve years. Balance, along with other factors such as hand-eye coordination, total body coordination and agility, which are not necessarily related to body size and strength, play a more decisive role. This is similar to the findings of Cunningham et al. (1976) on other ten year old hockey players.

What has not been discussed as of yet is the preferential influences of a season of competitive ice hockey on some functional abilities of hockey players as compared to the influences of a less competitive league on the same.

The Mite $A_1$ team had played some sixty games over the course of the season. In combination with this, the Mite $A_1$ team had also practiced two times a week and played additional tournament and exhibition games. The Mite $B_1$ team, on the other hand, had played some twenty-five games and practiced only once a week. The league in which the Mite $A_1$ team competed was by far the more competitive league demanding high levels of performance. The Mite $B_1$ league was more of a recreational league, whereby the play was observed to be slower and less intense. In light of the above points, does participation in a competitive leage of hockey cause a training effect on select functional capabilities in children?

In terms of grip strength, the Mite $A_1$ team scored slightly higher on both the left and right grips (Table VI). However, the differences

between the means were not significant ($p > .05$). As a result, the effects of a more competitive hockey season are not evident in this particular test. Montpetit et al. (1966) found that boys aged 10 years (N=53) scored 17.4 kg on the best of either left or right grip strength. The teams of the present investigation scored higher than the boys of Montpetit's investigation by as much as 4 kg (Mite $A_1$) and 3 kg (Mite $B_1$). However, the boys of the Mite $A_1$ and Mite $B_1$ teams were also taller by as much as 5 cm (Mite $A_1$) and 3.5 cm (Mite $B_1$). The difference in height might explain the discrepancy between the best mean grip strength scores. Bookwalter (1950) found that boys aged 10 years scored 21.8 kg on the left grip strength and 22.3 kg on the right grip strength. These scores are similar, yet higher than the mean scores obtained by the Mite $A_1$ and Mite $B_1$ teams on the right and left grip strength. It is evident that the grip strengths obtained by the Mite $A_1$ and $B_1$ teams are probably similar to grip strengths of other normally active children. As a result, there appears to be no influence of competitive ice hockey on grip strength in children. Nor does grip strength and its related factors play an influential role in overall general hockey ability.

The results of the CAHPER fitness performance tests were presented in Table VII. On all tests, the Mite $A_1$ team's means were higher. Only on the standing broad jump and shuttle run tests were the differences found not to be significant ($p > .05$). On the one minute speed sit-ups and flexed arm hang tests, the Mite $A_1$ team was significantly better at a probability level of .05. On the 50 and 300 yard runs, the differences between the means were significant at the .01 level. When the results were compared to the CAHPER fitness performance manual's norms, both teams placed extremely high. The Mite $A_1$ team fell into the 95% to 100%

level on the sit-ups, standing broad jump, 50 yard dash and 300 yard run. On the shuttle run and flexed arm hang, the percentile levels obtained were 80 to 85% and 90 to 100%, respectively. The Mite $B_1$ team also fell within the 95-100% level on the sit-ups and standing broad jump. On the flexed arm hang, 50 yard dash and 300 yard run, the Mite $B_1$ team obtained the level of 80-85%. On the shuttle run the level reached was 70-75%. As a result, both teams demonstrated superior capabilities as compared to the normal child population on this battery of tests. Both teams demonstrated their superiority over values reported by other investigators as well (Latchau, 1954; Cureton et al., 1976).

The possible cause of the significant differences found between teams on the one-minute speed sit-ups and flexed arm hang test was discussed earlier. The primary cause was attributed to motivation. However, in light of the fact that the one minute speed sit-up test measures specific hip and abdominal flexor muscle strength which, to a large extent, are used in the sport hockey, it is likely that the competitive hockey season (Mite $A_1$) had a partial effect on the strengths of these muscles. The non-significant difference found on the standing broad jump is evidence that the more competitive league does not elicit a training effect on explosive muscular power. The significant differences observed on the 50 yard dash and 300 yard run indicate the possibility that highly competitive hockey improves a player's anaerobic capabilities. This is probable, considering that Seliger et al.(1972) found that in adult hockey players, two-thirds of the energy was provided by anaerobic processes during actual game playing.

In terms of the physical work capacity test, the Mite $A_1$ team proved to be significantly better than the Mite $B_1$ team ($p < .01$)

(Table VIII). This was the case in either kpm/min or kpm/kg/min. Thus, the Mite $A_1$ team's superiority on this parameter was due to factors other than body weight ($p < .05$) (Table I). The heights and weights of both teams were comparable to data from other studies (Adams et al., 1961b; Tanner et al., 1966; Howell and Macnab, 1968; Welch et al., 1971).

When the $PWC_{170}$ values of the Mite $A_1$ and Mite $B_1$ teams are compared to values reported by others (Table XVI), the Mite $A_1$ team demonstrates superiority over other boys of similar age. This is particularly evident when the mean physical working capacities are expressed in terms of respective body weights. The Mite $B_1$ team was similar to other reported values, however, was below the value reported by Cunningham et al. (1976) on other hockey players aged 10 years.

In Shksvatsabaya's (1977) study, despite the fact that the hockey players were substantially lighter than both Mite teams, the 11 year old hockey players from Moscow were found to have superior physical work capacities (Tabel XVI). In light of this, Cunningham et al. (1976) found that 10 year old competitive ice hockey players have higher physical work capacities than reported values of normal healthy children (Table XVI).

It is evident that participation in the competitive sport of ice hockey may bring about positive adaptations on the cardiorespiratory fitness of children. However, it is possible that the children of the Mite $A_1$ team and those children of other investigations involved in hockey who demonstrated superior physical work capacities may have had possession of this quality prior to participation in the sport.

The final purpose of this investigation was to determine the overall best predictors of "in vivo" hockey performance. In order to do this, all the variables were correlated to hockey performance

TABLE XVI Physical Work Capacity of Selected Populations (males)

| | (N) | AGE (yr) $\bar{X}$ | WT (kg) $\bar{X}$ | $PWC_{170}$ kpm/min $\bar{X}$ | $PWC_{170}$ kpm/kg/min $\bar{X}$ |
|---|---|---|---|---|---|
| Adams et al. (1961a) (California) | ( 9) | 10 | 40.0 | 551 | 13.78 |
| Adams et al. (1961b) (Sweden) | (25) | 10 | 34.5 | 500 | 14.50 |
| Cumming & Cumming (1963) (Winnipeg) | ( 5) | 10 | 34.0 | 458 | 13.50 |
| Howell and Macnab (1968) (Canada) | (101) | 10 | 33.0 | 427 | 12.79 |
| Macek et al. (1971) (Prague) | (34) | 10 | 32.0 | 451 | 14.00 |
| Cunningham and Eynon (1973) (Ontario) Competitive swimmers | (10) | 11 | 42.0 | 851 | 20.52 |
| Cunningham et al. (1976) (Ontario)(Competitive hockey players) | (15) | 10 | 36.0 | 510 | 14.55 |
| Shkhvatsabaya (1977) (Moscow) (Competitive hockey players) | (26) | 11 | 27.0 | 505 | 18.56 |
| Present investigation Mite $A_1$ | (14) | 10 | 33.9 | 525 | 15.72 |
| Present investigation Mite $B_1$ | (14) | 10 | 33.6 | 449 | 13.39 |

(Appendix I). It was observed that the non-specific hockey variables did not correlate to "in vivo" hockey performance as did the specific hockey variables (i.e., the hockey test items). As discussed earlier, it was observed that from the hockey tests, the Macnab-Gill backward agility skate was able to differentiate the two teams more so than any other hockey test. The forward speed skate was the least differentiating hockey test. Therefore, it would appear that any of the hockey tests involving greater degrees of complexity to perform would serve as the better predictors of "in vivo" hockey ability.

When using correlation analyses, it must be kept in mind that a higher correlation does not demonstrate a cause and effect relationship but only indicates that a relationship between two variables exists. This relationship may be influential in nature or simply coincidental. On the other hand, a low correlation does not necessarily disprove an existing relationship between two variables. A low correlation may indicate a suppression of a particular variable's relationship to another by other existing factors, even though its influence may be substantial.

In the present investigation, a multiple regression analysis using stepwise procedures was utilized to develop the best predictor or predictors of "in vivo" hockey performance. Table XV depicts the best predictors of "in vivo" hockey performance. The modified Marcotte's test correlated the highest with "in vivo" hockey performance (Table XIV) and as a result it's r value was entered at the top of the procedure (Table XV). The only other test which was able to improve the multiple R by more than 4% was the Macnab-Gill backward agility test. These two variables on their own accounted for 86% of the variance of "in vivo" hockey performance. Jobin (1975) was unable to predict "in vivo" hockey

performance from the same variables studied in the present investigation. However, his investigation consisted of a very homogeneous group of subjects in terms of levels of performance. Considering that the present investigation had a more heterogeneous group of subjects in terms of levels of performance, a significant multiple R was produced that predicts "in vivo" hockey performance. It is therefore evident that whatever factors affect performance of the backward agility skate and Marcotte's puck control skate, are the same factors necessary for superior "in vivo" hockey performance.

Summary and Conclusions

In the current investigation, differences existing between two ice hockey teams participating in two different leagues of hockey were observed. One team, the Mite $A_1$ team, played in a league which was of a highly competitive nature requiring superior hockey playing abilities. The other team, the Mite $B_1$ team, played in a league which was of a recreational nature where a high degree of hockey proficiency was not required. When the games of each team were observed by this investigator, the Mite A league presented games that were, by far, more intense than the games of the Mite B league.

The two teams performed a number of hockey skill tests. The Mite $A_1$ team proved to be superior in test executions at both pre- and post-season. Thus is was found that the coaches' perceptions of hockey proficiency in team try-outs was validated. It was also found that the Mite $B_1$ team improved at a greater rate during the course of the season. A number of explanations were offered as to the reason for the occurence of this phenomenon. It was concluded that this occured because of a learning effect experienced by the Mite $B_1$ team. It was also attributed to a narrowing of the range of individual scores of the Mite $B_1$ team by post-season. In addition to these two explanations, it was conceivable that the Mite $A_1$ team experienced a ceiling effect in terms of motor-maturation. As a result, the Mite $A_1$ team did not have as much potential for improvement as did the Mite $B_1$ team. When the best results of the two teams were observed in the subsequent two years (Macnab, 1978), the differences between the two teams, at post-season, persisted. It was therefore further concluded that the aforementioned explanations concerning the differences in the rate of improvement on the hockey tests

could not explain entirely, the differences between the two teams at post-season. As a result, the Mite $A_1$ team's hockey proficiency was due to other factors. When the test results of both teams were compared to the limited findings of others (Hansen et al., 1970), the teams of the present investigation were observed to be superior.

The degree of individual differences for each team were found to be specific to the hockey test performed. The forward speed skate test did not differentiate the two teams as markedly as did the other hockey tests. The Macnab-Gill backward agility skate proved to be the most differentiating test. The forward speed skate did not correlate as highly to the coaches' subjective rankings of "in vivo" hockey performance as did the other hockey tests. Nor did the forward speed skate correlate with the other hockey tests as did these other hockey tests with one another. Therefore, it was apparent that factors affecting forward speed skating ability were not as important as other yet unexplained factors to overall superior hockey playing ability.

The determination of all of the physical fitness factors important to ice hockey proficiency was not within the scope of this investigation. It was, however, the intention of this investigation to determine some of the factors that were not important.

The finding was that superior body size and overall body strength were not determining factors for superior hockey playing abilities. This was illustrated by the fact that no significant difference was found between the two teams on height, weight and grip strength. However, the Mite $A_1$ team was significantly better on the flexed arm hang and speed sit-up tests. There was no significant difference on the standing broad jump. The significant differences on the flexed arm hang and speed

sit-up tests were attributed to the Mite $A_1$ team's higher levels of motivation considering that this team may have been accustomed to higher relative degrees of muscular discomfort due to the intensity of the games they played in. It was also hypothesized that the Mite $A_1$ team had acquired special techniques which allowed them to perform the flexed arm hang longer and speed sit-ups faster. As a result, it was concluded that dry land tests of strength, agility and explosive power do not differentiate individuals of varying level of hockey skills. It was evident then, that superiority in ice hockey is specific to the realm of the ice. It was proposed that such factors as balance, hand-eye and body coordination and agility specific to skating affect hockey proficiency. In any event, the statement that "practice makes perfect" may be highly regarded as the key overall factor determining overall hockey ability.

Another purpose of this investigation was to determine if partici-pation in a highly competitive, intense league of ice hockey produced any alterations in a child's physical fitness. As mentioned earlier, no significant difference was observed between the teams on the grip strength tests or the standing broad jump test. Explanations were offered to why significant differences existed on the flexed arm hang and speed sit-up test. However, the difference found on the sit-up test may not be entirely accomodated by the explanations offered. It is likely that intense games of ice hockey elicit improvements on strength in the muscles specifically used to skate. Considering that the sit-up test requires work to be performed by some of the same muscles required in skating, the latter point gains support. However, more elaborate testing would have to be performed on the specific muscles involved

in skating to further substantiate this theory. Therefore, it is possible that a child's participation in a highly competitive league of hockey does not elicit a greater training effect on the musculature than does a recreational league of hockey. However, as was evident when both the teams were compared to norms available on normally active children, involvement in the sport of ice hockey, highly competitive or not, may be causing an improvement on the musculature of children who participate.

It has been conclusively found that adult hockey players require large contributions from the anaerobic processes for superior performance in ice hockey. As a result, adult ice hockey players demonstrate high levels of anaerobic power and aerobic capacities. It has also been found that adult hockey players should possess high levels of aerobic powers for superior total game performance. This is because of the intermittent nature of the game. In the present investigation, members of the Mite $A_1$ team demonstrated significantly higher anaerobic powers (50 yard dash) and aerobic capacities (300 yard run) as compared to the Mite $B_1$ team. It was also found that the Mite $A_1$ team possessed superior aerobic powers ($PWC_{170}$). In light of these findings, it was evident that children playing in a competitive, intense league of ice hockey display anaerobic and aerobic capabilities similar to adult hockey players and superior to children who participate in a recreational league of ice hockey.

As to whether participation in an intense, competitive hockey league elicits a training effect on the musculature and aerobic and anaerobic capabilities was not within the scope of this investigation. This was due to the fact that pre-season testing of these parameters did not take place, as a result the initial fitness levels were not observed.

This investigator can only speculate that competitive hockey participation brings about these changes. It is evident however, that in order to compete in an organized, competitive ice hockey league, participants must possess superior levels of the parameters investigated.

The results of the multiple regression analysis produced only two tests from a total of 25 variables which predicted hockey performance. The tests were the modified Marcotte's puck control skate and the Macnab-Gill backward agility skate. Both these tests could explain 86% of "in vivo" hockey performance variance.

Based on the experimental results of the current investigation, the following conclusions appear justified:

1. Boys who participate in a competitive league of ice hockey possess superior hockey skills and skating abilities as compared to ice hockey players who participate in a recreational league of ice hockey.

2. The forward speed skating test does not differentiate hockey players who possess varying degrees of hockey abilities as do tests requiring a greater degree of skill. As a result, the forward speed skating test's usage as an instrument to screen children's hockey proficiency levels is questioned. It should only be used to measure linear speed on the ice.

3. The modified Marcotte's puck control skate and Macnab-Gill backward agility skate should be utilized as a test battery to measure overall hockey ability. The formula devised is:

$$\hat{y} = -67.15 + 37.71\ (X_1) + 2.14\ (X_2)$$

where $X_1$ = the modified Marcotte's puck control skate and

$X_2$ = the Macnab-Gill backward agility skate.

4. Boys who participate in a competitive league of ice hockey where superiority of hockey skills is a necessity do not necessarily require superior body size and strength.

5. Boys who participate in a competitive league of ice hockey require high levels of anaerobic and aerobic capabilities. This is similar to adult hockey players.

6. Boys who participate in ice hockey, highly competitive or not, are superior to age matched, normally active boys in terms of overall physical fitness. This includes muscular strength and endurance, muscular power and physical work capacity.

7. Participation in highly competitive ice hockey possibly elicits a training effect on the anaerobic and aerobic capabilities and strengths of specific muscle groups in boys.

8. The factors influencing the superior performance of hockey skills are specific to ice hockey.

## Recommendations

1. It is recommended that future research attempts be aimed at determining the factors that influence superior hockey abilities in children. It is suggested that a wide range of tests measuring all the components of physical fitness be employed and treated with factor analytical techniques. A large number of hockey players would be necessary.

2. It is recommended that large heterogeneous samples of hockey players be tested on the same hockey skill tests as used in this investigation. In turn, the subjects should be ranked in terms of "in vivo" hockey performance by a panel of hockey experts. As a result, through the use of proper analytical techniques, a test battery could be

devised to accurately screen boys of varying levels of hockey proficiency which could be used by Canadian hockey coaches.

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# APPENDIX A

CALIBRATION TABLE FOR THE BICYCLE ERGOMETER

| KP SETTING | CALIBRATION* |
|---|---|
| 0.5 | .200 |
| 1.0 | .410 |
| 1.5 | .630 |
| 2.0 | .850 |
| 2.5 | 1.060 |
| 3.0 | 1.280 |
| 3.5 | 1.500 |
| 4.0 | 1.720 |
| 4.5 | 1.930 |
| 5.0 | 2.140 |

* The calibration values indicate the number of kilograms required to raise the pendulum to successive scale markings.

N.B. In all PWC 170 tests, a small modified pendulum was employed as described by Howell and Macnab (1968)

APPENDIX B

COMPUTER PROGRAM

PWC AND ESTIMATED $MVO_2$ VALUES

```
     WCT ( )
     WCT
( 1) N pHR
( 2) SC +/HR
( 3) WL PR 6 KP
( 4) SY +/WL
( 5) 6
( 6) SXSY SX SY
( 7) SXS +/ (HR*2)
( 8) SYSY +/ (HR WL)
( 9) BX (XYXY-(SXSY N))
(10) BYX BX (SXS-((SX*2) N))
(11) AYX (SY-(BYX SX)) N
(12) PWF (BYX 1 50)+AYX
(13) PWS (BYX 170)+AYX
(14) PWZ (BYX 135)+AYX
(15) PWB BYX 165)+AYX
(16) (S=2)/26
(17) VOL (0.003 PWF)+0.5
(18) (VOL 3.7)/22
(19) (VOL 4.7)/24
(20) VOL VOL+0.1
(21) 25
(22) VOL VOL+0
(23) 25
(24) VOL VOL+0.2
(25) 27
(26) VOL (0.00334 PWF) 0.5
(27) ACF 1.2-(0.00913 AG)
(28) CVL VOL ACF
(29) VMK (CVL KG) 1000
(30) "SUBJECTS ID IS"; ID
(31) "PWC 150 IS"; PWF
(32) "PWC 170 IS"; PWS
(33) "PWC 135 IS"; PWA
(34) "PWC 165 IS"; PWB
(35) "PWC 170/KG IS"; PWS KG
(36) "VO2 IN LIT IS"; VOL
(37) "AGE FACTOR IS"; ACF
(38) "VO2 IN LIT COR FOR AGE IS"; CUL
(39) "VO2 IN ML/KG/MIN IS"; VMK
```

# APPENDIX C

MITE $A_1$ SUBJECTS

| NAME | I.D. # | DATE OF BIRTH (DAY,MONTH,YEAR) |
|---|---|---|
| ANTONIUK, M. | 1 | 12-01-65 |
| CARLSON, R. | 2 | 11-06-65 |
| DONADT, R. | 3 | 26-03-65 |
| DONALD, S. | 4 | 24-06-65 |
| HOLGATE, B. | 5 | 16-12-65 |
| JONES, B. | 6 | 06-09-65 |
| LEISEN, B. | 7 | 13-07-65 |
| LUND, G. | 8 | 12-07-65 |
| LUND, T. | 9 | 12-07-65 |
| MACNAB, B. | 10 | 16-07-65 |
| MILLIGAN, P. | 11 | 21-04-65 |
| PARKER, G. | 12 | 09-04-65 |
| ROBERGE, D. | 13 | 15-02-65 |
| TKACHUK, S. | 14 | 25-02-65 |

MITE $B_1$ SUBJECTS

| NAME | I.D. # | DATE OF BIRTH (DAY,MONTH, YEAR) |
|---|---|---|
| BELKE, B. | 15 | 01-02-65 |
| BELKE, M. | 16 | 01-02-65 |
| BLADE, D. | 17 | 27-10-65 |
| CHRISTENSON, C. | 18 | 31-08-65 |
| DISHAW, T. | 19 | 14-09-65 |
| ENNS, R. | 20 | 13-07-65 |
| KUCHER, N. | 21 | 19-04-65 |
| MARTIN,D. | 22 | 09-04-65 |
| NAHORNIUK, D. | 23 | 28-07-65 |
| PAWLIUK, D. | 24 | 06-05-65 |
| SMALL, D. | 25 | 23-08-65 |
| WORKUM, J. | 26 | 10-03-65 |
| WOZNIAK, L. | 27 | 03-09-65 |
| YUEN, L. | 28 | 27-08-65 |

# APPENDIX D

AGE, HEIGHT AND WEIGHT FOR THE
MITE $A_1$ SUBJECTS

| I.D. # | AGE (years) | HEIGHT (cm) | WEIGHT (kg) |
|---|---|---|---|
| 1 | 11.21 | 153.16 | 42.77 |
| 2 | 10.80 | 145.54 | 32.96 |
| 3 | 11.00 | 143.51 | 33.18 |
| 4 | 10.76 | 152.40 | 42.96 |
| 5 | 10.28 | 142.49 | 29.77 |
| 6 | 10.56 | 143.51 | 34.09 |
| 7 | 10.71 | 153.67 | 39.09 |
| 8 | 10.71 | 139.95 | 30.23 |
| 9 | 10.71 | 137.16 | 27.50 |
| 10 | 10.70 | 140.97 | 30.46 |
| 11 | 10.93 | 139.70 | 31.59 |
| 12 | 10.97 | 147.32 | 35.00 |
| 13 | 11.12 | 138.43 | 30.68 |
| 14 | 11.09 | 138.43 | 34.55 |
| Mean | 10.84 | 144.02 | 33.92 |
| S.D. | 0.25 | 5.66 | 4.72 |

AGE, HEIGHT AND WEIGHT OF THE
MITE $B_1$ SUBJECTS

| I.D.# | AGE (years) | HEIGHT (cm) | WEIGHT (kg) |
|---|---|---|---|
| 15 | 11.16 | 146.05 | 34.32 |
| 16 | 11.16 | 145.29 | 34.64 |
| 17 | 10.42 | 137.92 | 31.14 |
| 18 | 10.57 | 144.78 | 35.46 |
| 19 | 10.54 | 143.00 | 32.50 |
| 20 | 10.71 | 137.16 | 33.18 |
| 21 | 10.94 | 146.05 | 43.64 |
| 22 | 10.97 | 143.51 | 32.27 |
| 23 | 10.67 | 135.38 | 29.55 |
| 24 | 10.89 | 140.97 | 29.77 |
| 25 | 10.60 | 148.59 | 37.05 |
| 26 | 11.05 | 145.03 | 33.41 |
| 27 | 10.57 | 144.78 | 34.09 |
| 28 | 10.58 | 137.16 | 30.00 |
| Mean | 10.77 | 142.55 | 33.64 |
| S.D. | 0.25 | 4.11 | 3.63 |

# APPENDIX E

PRE- AND POST-SEASON RESULTS OF THE HOCKEY TESTS
FOR MITE $A_1$ SUBJECTS

| I.D.# | | FRONT SKATE 60' | 90' | 120' | BACK SKATE 60' | 90' | 120' | AGILITY | MARCOTTE | HANSEN | MACNAB -GILL |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Pre | 3.2 | 4.4 | 5.7 | 4.0 | 5.8 | 7.6 | 10.5 | 14.9 | 18.0 | 10.2 |
| | Post | 2.9 | 4.1 | 5.3 | 3.9 | 5.5 | 7.3 | 8.8 | 13.5 | 16.8 | 8.4 |
| 2 | Pre | 3.2 | 4.9 | 5.4 | 4.7 | 6.8 | 8.3 | 12.2 | 17.9 | 22.0 | 11.6 |
| | Post | 3.0 | 4.3 | 5.6 | 3.8 | 5.4 | 7.1 | 9.1 | 15.6 | 18.7 | 8.6 |
| 3 | Pre | 2.8 | 4.2 | 5.3 | 4.1 | 5.8 | 7.2 | 11.9 | 15.6 | 19.8 | 10.9 |
| | Post | 2.7 | 4.0 | 5.2 | 3.7 | 5.6 | 7.1 | 9.8 | 15.4 | 22.5 | 9.0 |
| 4 | Pre | 3.0 | 4.6 | 5.5 | 4.3 | 6.5 | 7.5 | 12.6 | 17.6 | 23.5 | 11.9 |
| | Post | 2.8 | 4.1 | 5.3 | 4.1 | 5.8 | 7.6 | 9.4 | 15.5 | 21.5 | 9.4 |
| 5 | Pre | 3.1 | 4.6 | 5.3 | 4.1 | 6.0 | 7.5 | 11.4 | 16.6 | 22.0 | 11.2 |
| | Post | 3.0 | 4.3 | 5.7 | 4.0 | 5.7 | 7.4 | 9.4 | 14.8 | 19.1 | 9.4 |
| 6 | Pre | 2.8 | 4.3 | 5.4 | 4.6 | 6.7 | 7.5 | 13.0 | 17.0 | 21.5 | 11.7 |
| | Post | 2.9 | 4.1 | 5.4 | 4.1 | 6.1 | 7.9 | 9.9 | 15.9 | 19.3 | 9.7 |
| 7 | Pre | 3.0 | 4.7 | 5.5 | 4.3 | 6.6 | 8.1 | 12.0 | 16.4 | 22.6 | 11.0 |
| | Post | 2.8 | 4.0 | 5.3 | 4.0 | 5.8 | 7.2 | 9.2 | 15.2 | 19.4 | 9.0 |
| 8 | Pre | 3.3 | 4.6 | 5.5 | 4.4 | 6.5 | 8.0 | 11.5 | 16.5 | 20.4 | 10.8 |
| | Post | 2.9 | 4.3 | 5.6 | 4.0 | 5.9 | 7.8 | 9.6 | 14.9 | 17.9 | 9.0 |
| 9 | Pre | 3.3 | 4.9 | 5.4 | 4.1 | 6.0 | 7.6 | 11.2 | 15.6 | 21.5 | 11.0 |
| | Post | 3.1 | 4.5 | 5.8 | 4.1 | 5.7 | 7.3 | 9.3 | 16.5 | 19.8 | 8.8 |
| 10 | Pre | 2.9 | 4.7 | 5.5 | 4.1 | 6.1 | 7.7 | 11.1 | 15.4 | 20.6 | 10.2 |
| | Post | 2.9 | 4.1 | 5.6 | 4.0 | 5.9 | 7.7 | 9.1 | 14.2 | 18.6 | 8.6 |
| 11 | Pre | 3.1 | 4.7 | 5.5 | 4.7 | 7.1 | 8.9 | 12.7 | 16.4 | 21.2 | 11.0 |
| | Post | 3.0 | 4.3 | 5.6 | 4.8 | 6.8 | 8.9 | 9.5 | 15.6 | 19.2 | 9.9 |
| 12 | Pre | 3.2 | 4.6 | 5.8 | 5.1 | 6.8 | 8.4 | 10.7 | 18.0 | 23.4 | 11.9 |
| | Post | 2.9 | 4.2 | 5.5 | 4.5 | 6.3 | 7.9 | 9.1 | 14.8 | 20.3 | 9.7 |
| 13 | Pre | 2.9 | 4.4 | 5.7 | 4.6 | 6.6 | 8.6 | 11.9 | 15.7 | 20.7 | 11.2 |
| | Post | 3.0 | 4.2 | 5.4 | 3.9 | 5.6 | 7.3 | 9.4 | 15.0 | 19.0 | 9.3 |
| 14 | Pre | 3.0 | 4.5 | 5.7 | 4.1 | 6.2 | 7.4 | 11.8 | 16.6 | 21.7 | 11.0 |
| | Post | 2.9 | 4.2 | 5.3 | 4.2 | 6.0 | 7.5 | 8.8 | 14.4 | 18.5 | 9.0 |
| Pre-Mean | | 3.06 | 4.58 | 5.51 | 4.37 | 6.39 | 7.88 | 11.75 | 16.44 | 21.35 | 11.12 |
| S.D. | | 0.17 | 0.20 | 0.16 | 0.32 | 0.41 | 0.51 | 0.74 | 0.95 | 1.44 | 0.53 |
| Post-Mean | | 2.91 | 4.19 | 5.47 | 4.08 | 5.86 | 7.57 | 9.31 | 15.09 | 19.33 | 9.13 |
| S.D. | | 0.10 | 0.14 | 0.18 | 0.28 | 0.36 | 0.47 | 0.33 | 0.76 | 1.42 | 0.46 |

PRE- AND POST-SEASON RESULTS OF THE HOCKEY TESTS
FOR MITE $B_1$ SUBJECTS

| I.D.# | | FRONT SKATE 60' | 90' | 120' | BACK SKATE 60' | 90' | 120' | AGILITY | MARCOTTE | HANSEN | MACNAB-GILL |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 15 | Pre | 3.2 | 4.7 | 5.8 | 4.9 | 6.8 | 8.9 | 13.4 | 19.2 | 23.5 | 16.1 |
| | Post | 3.0 | 4.4 | 5.7 | 4.6 | 6.6 | 8.5 | 11.8 | 18.5 | 22.1 | 10.5 |
| 16 | Pre | 3.5 | 4.7 | 6.0 | 5.5 | 7.4 | 9.1 | 12.6 | 16.8 | 25.5 | 14.4 |
| | Post | 3.0 | 4.2 | 5.6 | 4.7 | 6.6 | 8.4 | 10.0 | 16.5 | 21.5 | 10.4 |
| 17 | Pre | 3.4 | 4.9 | 6.0 | 5.6 | 7.4 | 9.3 | 11.9 | 17.4 | 31.2 | 13.9 |
| | Post | 3.2 | 4.6 | 5.6 | 4.6 | 6.5 | 8.4 | 10.3 | 16.6 | 22.7 | 10.3 |
| 18 | Pre | 3.2 | 4.8 | 5.9 | 4.8 | 6.5 | 8.5 | 11.7 | 19.0 | 29.3 | 12.5 |
| | Post | 2.9 | 4.3 | 5.4 | 4.3 | 6.6 | 7.8 | 9.4 | 16.4 | 21.4 | 9.0 |
| 19 | Pre | 3.5 | 4.7 | 6.2 | 5.6 | 7.7 | 9.8 | 14.0 | 26.0 | 30.5 | 18.0 |
| | Post | 3.0 | 4.5 | 5.9 | 5.2 | 7.4 | 9.6 | 10.8 | 17.5 | 23.5 | 12.6 |
| 20 | Pre | 3.1 | 5.0 | 6.2 | 5.0 | 7.4 | 9.1 | 12.5 | 18.5 | 24.4 | 15.0 |
| | Post | 3.0 | 4.4 | 5.7 | 4.0 | 5.7 | 7.6 | 10.5 | 17.3 | 23.2 | 11.8 |
| 21 | Pre | 3.4 | 4.5 | 6.0 | 4.5 | 6.1 | 8.0 | 12.9 | 19.6 | 23.2 | 12.7 |
| | Post | 2.9 | 4.3 | 5.7 | 4.7 | 6.7 | 8.7 | 10.3 | 17.0 | 21.0 | 11.3 |
| 22 | Pre | 3.6 | 5.0 | 6.2 | 6.4 | 9.1 | 11.9 | 12.8 | 19.0 | 25.5 | 14.1 |
| | Post | 3.0 | 4.3 | 5.6 | 4.6 | 6.4 | 8.6 | 10.5 | 17.0 | 22.1 | 10.3 |
| 23 | Pre | 3.6 | 5.0 | 6.9 | 7.0 | 10.1 | 13.0 | 15.2 | 20.8 | 29.5 | 19.9 |
| | Post | 3.0 | 4.5 | 5.7 | 5.1 | 7.2 | 9.5 | 10.6 | 17.9 | 20.3 | 13.5 |
| 24 | Pre | 3.2 | 4.2 | 6.0 | 4.9 | 7.0 | 9.1 | 11.5 | 17.9 | 20.6 | 13.5 |
| | Post | 3.0 | 4.4 | 5.7 | 4.4 | 6.4 | 8.3 | 10.4 | 16.2 | 21.2 | 10.9 |
| 25 | Pre | 3.4 | 5.0 | 6.5 | 4.8 | 7.4 | 9.5 | 12.4 | 19.7 | 29.5 | 12.6 |
| | Post | 3.0 | 4.3 | 5.5 | 4.4 | 6.1 | 7.9 | 9.8 | 17.3 | 23.7 | 10.2 |
| 26 | Pre | 3.4 | 4.8 | 5.9 | 5.3 | 7.4 | 9.4 | 13.5 | 10.5 | 26.8 | 13.5 |
| | Post | 2.9 | 4.2 | 5.4 | 4.3 | 6.0 | 8.0 | 10.2 | 17.5 | 22.5 | 10.4 |
| 27 | Pre | 3.2 | 4.7 | 5.6 | 4.5 | 6.6 | 7.2 | 12.6 | 18.2 | 26.7 | 12.5 |
| | Post | 3.0 | 4.2 | 5.6 | 4.4 | 6.4 | 8.2 | 10.3 | 16.8 | 21.7 | 11.5 |
| 28 | Pre | 4.0 | 5.4 | 6.8 | 7.4 | 10.7 | 14.9 | 15.4 | 23.0 | 29.0 | 19.6 |
| | Post | 3.3 | 4.8 | 6.1 | 5.1 | 7.5 | 9.6 | 11.0 | 18.8 | 25.0 | 14.0 |
| Pre-Mean | | 3.41 | 4.81 | 6.14 | 5.44 | 7.69 | 9.84 | 13.03 | 19.61 | 26.80 | 14.88 |
| S.D. | | 0.23 | 0.28 | 0.37 | 0.90 | 1.35 | 2.06 | 1.18 | 2.38 | 3.16 | 2.57 |
| Post-Mean | | 3.01 | 4.39 | 5.66 | 4.60 | 6.58 | 8.51 | 10.42 | 17.24 | 22.28 | 11.19 |
| S.D. | | 0.11 | 0.17 | 0.18 | 0.34 | 0.51 | 0.65 | 0.56 | 0.77 | 1.26 | 1.38 |

# APPENDIX F

GRIP STRENGTH MEASURES FOR MITE $A_1$ SUBJECTS

| I.D. # | LEFT GRIP (kg) | RIGHT GRIP (kg) |
|---|---|---|
| 1 | 25 | 23 |
| 2 | 20 | 22 |
| 3 | 19 | 22 |
| 4 | 26 | 26 |
| 5 | 20 | 21 |
| 6 | 19 | 20 |
| 7 | 18 | 19 |
| 8 | 19 | 19 |
| 9 | 16 | 19 |
| 10 | 16 | 18 |
| 11 | 22 | 20 |
| 12 | 21 | 21 |
| 13 | 18 | 20 |
| 14 | 22 | 25 |
| Mean | 20.07 | 21.07 |
| S.D. | 2.95 | 2.34 |

GRIP STENGTH MEASURES FOR MITE $B_1$ SUBJECTS

| I.D. # | LEFT GRIP (kg) | RIGHT GRIP (kg) |
|---|---|---|
| 15 | 20 | 20 |
| 16 | 19 | 20 |
| 17 | 14 | 16 |
| 18 | 21 | 24 |
| 19 | 20 | 20 |
| 20 | 20 | 18 |
| 21 | 24 | 23 |
| 22 | 19 | 20 |
| 23 | 18 | 15 |
| 24 | 17 | 17 |
| 25 | 19 | 21 |
| 26 | 26 | 24 |
| 27 | 18 | 23 |
| 28 | 16 | 18 |
| Mean | 19.36 | 19.93 |
| S.D. | 3.03 | 2.90 |

# APPENDIX G

C.A.H.P.E.R. FITNESS PERFORMANCE SCORES FOR MITE $A_1$ SUBJECTS

| I.D. # | ONE MINUTE SPEED SIT-UPS (no.) | STD BROAD JUMP (inches) | SHUTTLE RUN (secs) | FL. ARM HANG (secs) | 50 YD DASH (secs) | 300 YD DASH (secs) |
|---|---|---|---|---|---|---|
| 1 | 52 | 72.5 | 11.4 | 78.0 | 8.0 | 60.0 |
| 2 | 54 | 68.0 | 11.1 | 70.0 | 7.8 | 60.8 |
| 3 | 64 | 74.0 | 11.8 | 70.0 | 7.8 | 64.1 |
| 4 | 45 | 63.0 | 11.7 | 64.0 | 7.6 | 58.2 |
| 5 | 47 | 72.0 | 11.7 | 86.0 | 7.6 | 61.0 |
| 6 | 42 | 63.5 | 12.4 | 70.0 | 7.7 | 67.8 |
| 7 | 43 | 62.0 | 11.2 | 26.0 | 8.2 | 65.8 |
| 8 | 46 | 64.5 | 11.2 | 83.0 | 7.8 | 61.2 |
| 9 | 49 | 65.0 | 11.5 | 87.0 | 7.9 | 63.5 |
| 10 | 43 | 64.5 | 12.8 | 84.0 | 7.9 | 62.6 |
| 11 | 54 | 63.0 | 12.3 | 52.0 | 7.8 | 62.6 |
| 12 | 46 | 69.5 | 11.4 | 45.0 | 7.5 | 58.5 |
| 13 | 48 | 67.5 | 11.0 | 59.0 | 7.4 | 59.3 |
| 14 | 43 | 65.0 | 11.7 | 33.0 | 8.0 | 67.2 |
| Mean | 48.29 | 66.71 | 11.66 | 64.79 | 7.79 | 62.33 |
| S.D. | 6.03 | 3.93 | 0.53 | 19.62 | 0.21 | 3.07 |

C.A.H.P.E.R. FITNESS PERFORMANCE SCORES FOR MITE $B_1$ SUBJECTS

| I.D. # | ONE MINUTE SPEED SIT-UPS (no.) | STD BROAD JUMP (inches) | SHUTTLE RUN (secs) | FL. ARM HANG (secs) | 50 YD DASH (secs) | 300 YD RUN (secs) |
|---|---|---|---|---|---|---|
| 15 | 45 | 67.0 | 11.8 | 36.0 | 8.4 | 65.7 |
| 16 | 38 | 67.0 | 11.6 | 29.0 | 7.6 | 62.8 |
| 17 | 45 | 63.0 | 12.0 | 26.0 | 8.5 | 65.9 |
| 18 | 36 | 65.0 | 12.0 | 45.0 | 8.2 | 67.7 |
| 19 | 40 | 65.5 | 11.1 | 39.0 | 7.9 | 61.3 |
| 20 | 38 | 61.0 | 11.6 | 60.0 | 8.1 | 68.9 |
| 21 | 37 | 61.0 | 12.9 | 48.0 | 8.6 | 68.8 |
| 22 | 36 | 64.0 | 11.9 | 66.0 | 8.8 | 66.1 |
| 23 | 52 | 63.0 | 11.8 | 71.0 | 7.8 | 65.0 |
| 24 | 36 | 66.0 | 12.0 | 91.0 | 8.1 | 64.2 |
| 25 | 47 | 67.0 | 12.2 | 53.0 | 8.2 | 67.1 |
| 26 | 62 | 71.0 | 12.0 | 42.0 | 7.4 | 64.1 |
| 27 | 44 | 66.0 | 11.9 | 59.0 | 8.2 | 69.8 |
| 28 | 32 | 66.0 | 11.9 | 30.0 | 8.0 | 67.0 |
| Mean | 42.00 | 65.18 | 11.91 | 49.64 | 8.13 | 66.03 |
| S.D. | 7.92 | 2.66 | 0.39 | 18.38 | 0.38 | 2.42 |

APPENDIX H

PHYSICAL WORK CAPACITY VALUES FOR MITE $A_1$ SUBJECTS

| I.D. # | PWC 170 (kpm/min) | BODY WEIGHT (kg) | PWC 170 (kpm/kg/min) |
|---|---|---|---|
| 1 | 487.06 | 42.77 | 11.39 |
| 2 | 508.54 | 32.96 | 15.43 |
| 3 | 570.31 | 33.18 | 17.19 |
| 4 | 539.42 | 42.96 | 12.56 |
| 5 | 483.35 | 29.77 | 16.24 |
| 6 | 568.26 | 34.09 | 16.67 |
| 7 | 519.89 | 39.09 | 13.30 |
| 8 | 493.86 | 30.23 | 16.34 |
| 9 | 501.11 | 27.50 | 18.22 |
| 10 | 500.72 | 30.46 | 16.44 |
| 11 | 435.45 | 31.59 | 13.78 |
| 12 | 603.19 | 35.00 | 17.23 |
| 13 | 561.38 | 30.68 | 18.30 |
| 14 | 588.89 | 34.55 | 17.04 |
| Mean | 525.82 | 33.92 | 15.72 |
| S.D. | 47.45 | 4.72 | 2.14 |

PHYSICAL WORK CAPACITY VALUES FOR MITE $B_1$ SUBJECTS

| I.D.# | PWC 170 (kpm/min) | BODY WEIGHT (kg) | PWC 170 (kpm/kg/min) |
|---|---|---|---|
| 15 | 567.91 | 34.32 | 16.55 |
| 16 | 532.95 | 34.64 | 15.39 |
| 17 | 420.66 | 31.14 | 13.51 |
| 18 | 323.62 | 35.46 | 9.13 |
| 19 | 350.81 | 32.50 | 10.79 |
| 20 | 444.12 | 33.18 | 13.39 |
| 21 | 563.92 | 43.64 | 12.92 |
| 22 | 400.29 | 32.27 | 12.40 |
| 23 | 381.78 | 29.55 | 12.92 |
| 24 | 497.18 | 29.77 | 16.70 |
| 25 | 451.71 | 37.05 | 12.19 |
| 26 | 414.05 | 33.41 | 12.39 |
| 27 | 473.91 | 34.09 | 13.90 |
| 28 | 458.55 | 30.00 | 15.29 |
| Mean | 448.67 | 33.64 | 13.39 |
| S.D. | 74.29 | 3.63 | 2.11 |

APPENDIX I

INTERCORRELATIONS OF ALL VARIABLES UNDER CONSIDERATION

| VARIABLE | PER | AGE | HT | WT | 60' FOR | 90' FOR | 120' FOR | 60' BACK | 90' BACK | 120' BACK | AGIL | MOD MAR | HAN MOD | BACK AGIL | STD L J | F.A. HANG | SIT UPS | SHU RUN | 50 YD | 300 YD | RT GRIP | LT GRIP | PWC kpm/ min | PWC kpm/kg/ min |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Performance | 1.00 | -.28 | -.21 | -.15 | .49 | .59 | .66 | .66 | .69 | .87 | .90 | .73 | .85 | -.27 | -.27 | -.30 | -.41 | .14 | .38 | .54 | -.32 | -.21 | -.46 | -.34 |
| Age (yrs) | | 1.00 | .28 | .36 | -.36 | -.40 | -.40 | -.13 | -.20 | -.16 | -.10 | -.19 | -.21 | -.25 | .24 | -.11 | .24 | -.13 | -.13 | -.28 | .35 | .49 | .46 | .17 |
| Height (cm) | | | 1.00 | .81 | -.55 | -.61 | -.51 | -.25 | -.28 | -.32 | -.26 | -.26 | -.11 | -.36 | .24 | -.14 | .09 | -.08 | .05 | -.21 | .56 | .53 | .22 | -.37 |
| Weight (kg) | | | | 1.00 | -.51 | -.49 | -.49 | -.13 | -.15 | -.19 | -.20 | -.18 | -.06 | -.19 | -.05 | -.27 | -.06 | .12 | .19 | .02 | .62 | .68 | .26 | -.47 |
| 60' For Skate (sec) | | | | | 1.00 | .88 | .78 | .52 | .48 | .51 | .43 | .52 | .36 | .53 | -.19 | -.19 | -.37 | .00 | .22 | .19 | -.52 | -.53 | -.34 | .05 |
| 90' For Skate (sec) | | | | | | 1.00 | .85 | .64 | .62 | .65 | .58 | .67 | .49 | .67 | -.26 | -.17 | -.36 | -.01 | .27 | .22 | -.52 | -.42 | -.46 | -.07 |
| 120' For Skate (sec) | | | | | | | 1.00 | .63 | .61 | .67 | .59 | .61 | .40 | .68 | -.26 | -.01 | -.46 | .07 | .21 | .16 | -.54 | -.43 | -.33 | .04 |
| 60' Back Skate (sec) | | | | | | | | 1.00 | .96 | .96 | .63 | .67 | .52 | .80 | -.33 | -.47 | -.38 | .21 | .25 | .23 | -.32 | -.11 | -.43 | -.34 |
| 90' Back Skate (sec) | | | | | | | | | 1.00 | .96 | .64 | .66 | .52 | .79 | -.33 | -.46 | -.44 | .27 | .27 | .31 | -.32 | -.18 | -.44 | -.33 |
| 120' Back Skate (sec) | | | | | | | | | | 1.00 | .71 | .68 | .51 | .84 | -.34 | -.34 | -.37 | .27 | .25 | .24 | -.38 | -.14 | -.46 | -.32 |
| Agility Skate (sec) | | | | | | | | | | | 1.00 | .88 | .72 | .77 | -.20 | -.28 | -.30 | .18 | .39 | .44 | -.38 | -.21 | -.28 | -.15 |
| Modified Marcotte (sec) | | | | | | | | | | | | 1.00 | .81 | .79 | -.28 | -.38 | -.27 | .19 | .34 | .53 | -.28 | -.18 | -.42 | -.28 |
| Hansen Modified (sec) | | | | | | | | | | | | | 1.00 | .66 | -.09 | -.46 | -.27 | .18 | .29 | .42 | -.12 | -.16 | -.36 | -.31 |
| Back Agility Skate (sec) | | | | | | | | | | | | | | 1.00 | -.29 | -.30 | -.36 | .13 | .18 | .39 | -.41 | -.19 | -.39 | -.26 |
| Standing Long Jump (in) | | | | | | | | | | | | | | | 1.00 | .19 | .56 | -.27 | -.43 | -.42 | .31 | .20 | .18 | .22 |
| Flexed Arm Hang (sec) | | | | | | | | | | | | | | | | 1.00 | .22 | .04 | -.19 | -.29 | -.11 | -.06 | .05 | .28 |
| Speed Sit-ups (no) | | | | | | | | | | | | | | | | | 1.00 | -.16 | -.47 | -.37 | .19 | .27 | .11 | .14 |
| Shuttle Run (sec) | | | | | | | | | | | | | | | | | | 1.00 | .35 | .51 | .00 | .02 | -.04 | -.13 |
| 50 Yard Run (sec) | | | | | | | | | | | | | | | | | | | 1.00 | .64 | -.15 | -.22 | -.24 | -.36 |
| 300 Yard Run (sec) | | | | | | | | | | | | | | | | | | | | 1.00 | -.10 | -.23 | -.20 | -.23 |
| Right Grip (kg) | | | | | | | | | | | | | | | | | | | | | 1.00 | .77 | .23 | -.23 |
| Left Grip (kg) | | | | | | | | | | | | | | | | | | | | | | 1.00 | .09 | -.39 |
| PWC 170 (kpm/min) | | | | | | | | | | | | | | | | | | | | | | | 1.00 | .73 |
| PWC 170 (kpm/kg/min) | | | | | | | | | | | | | | | | | | | | | | | | 1.00 |

Critical r's .05 = .37

.01 = .48